Model-based Approaches for Interoperability of Next Generation Organization Information Systems: State of the Art and Future Challenges

Institute Mines & Telecom (IMT) – Ecole des Mines d'Alès

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- **Professor at IMT** (September 2018): **École des Mines d'Alès** and **LGI2P laboratory**

- **HDR** (2014) "**Model Transformation, Semantic Approach & Simulation – Contribution to the Interoperability of Enterprise Systems**" University of Bordeaux

- **Associate Professor (September 2007) at the IMS** laboratory **(UMR CNRS 5218) and at** the University of Bordeaux (IUT Physical Measurements)

- **PhD Thesis** (2006) «**A G-DEVS/HLA Environment: Application to Workflow Modelling and Distributed Simulation**» Université Aix-Marseille

➔ Research: **Modelling, Simulation and Interoperability of Complex Systems**

  › **Model Driven Information Systems Engineering, Distributed Simulation, Semantics**, **Multidimensional Social Networks**.

Alès : une fresque humaine pour lancer les festivités des 175 ans de l'Ecole des Mines

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8 partages Education, Alès

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Agenda

1. Need for Interoperability in large System Design and Execution
2. Interoperability -> Driving System Design and Implementation
   - 2.0 Model Based Methodology [Zacharewicz et al. 2016]
   - 2.1 Horizontal / Vertical Down Interoperability Models for validation processing scenario by simulation
   - 2.2 Model Matching Approaches (Horizontal Semantic Interoperability)
   - 2.3 Interoperability at Execution Time
   - 2.4 Model Driven Approaches (Driving down Vertical Interoperability)
   - 2.5 Model Discovery with Traces and data Mining for better Reuse
   - 2.6 Organizational & Social Interoperability
3. Conclusion

1. Need for Interoperability in large System Design and Execution

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Industrial Engineering with B2B and B2C coupling

Connect Activities in the same enterprise or between enterprises

Have a common view, common understanding, be aligned,

Connect Activities between teams, B2B or B2C, Asynchronous activities.

A Need for heterogeneous Data Exchange & Integration (Data structure and Models)

Scientific Issues: Modelling & Interoperability

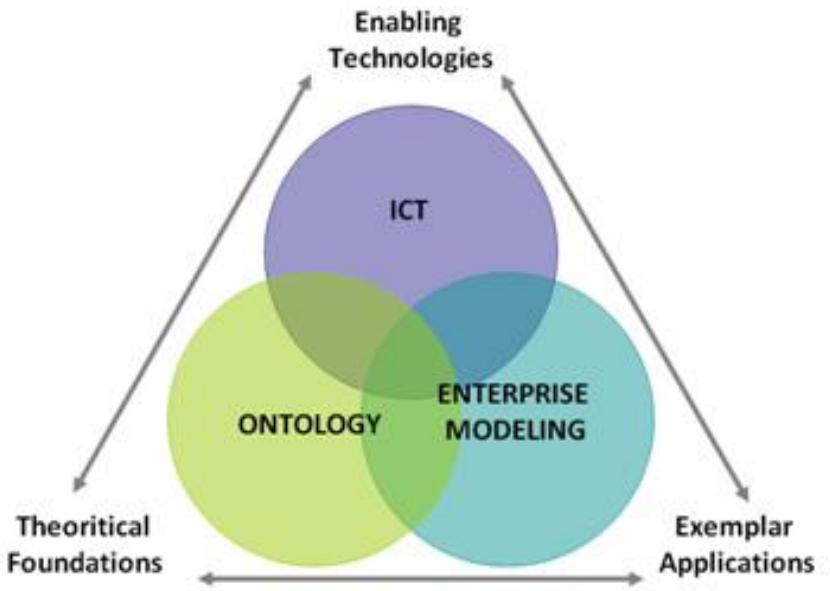
- *"The ability of two or more systems or components to exchange information and to use the information that has been exchanged."*

***IEEE** Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries (New York, NY: 1990).*

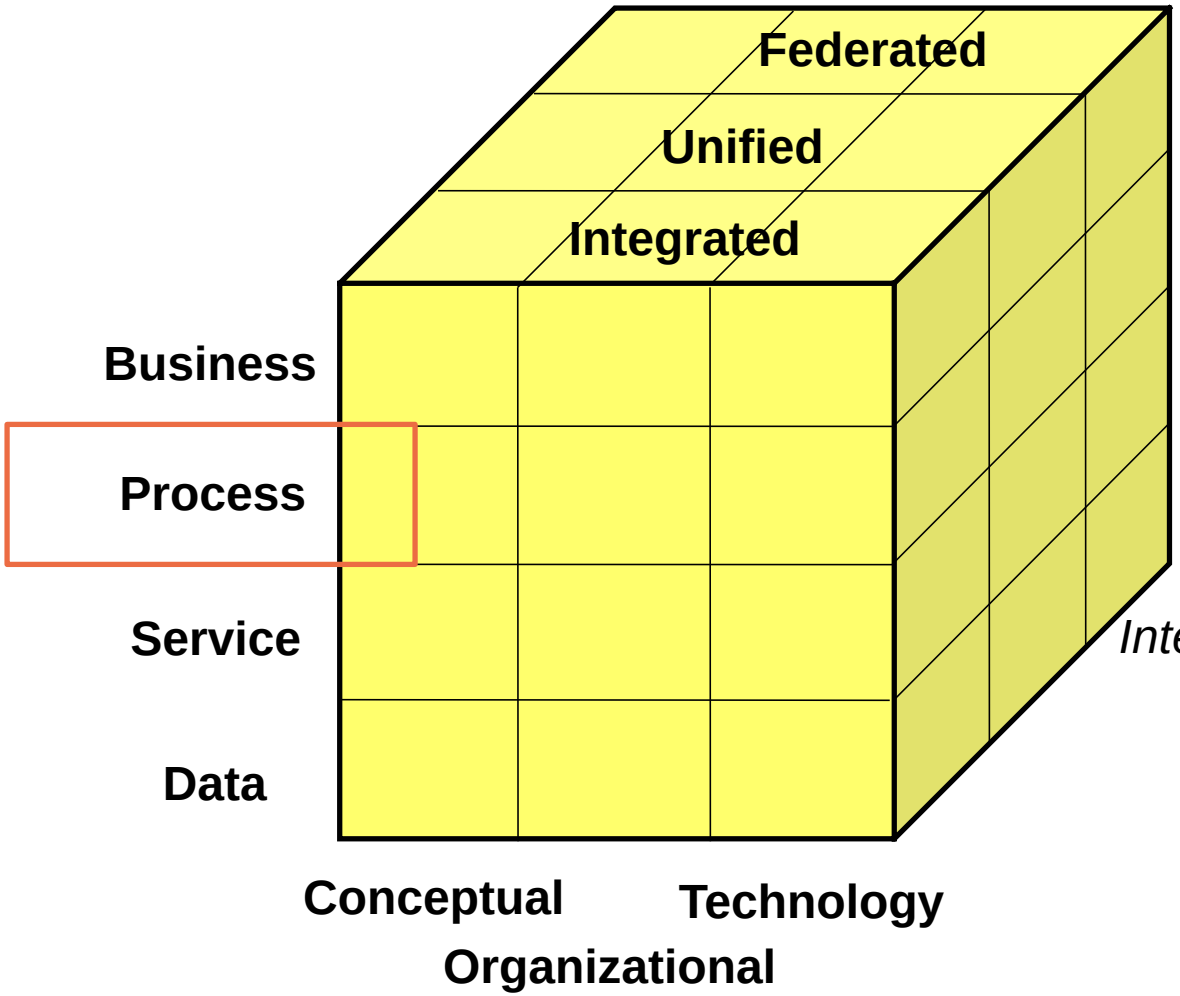
- *"Enterprises are not interoperable because there are barriers to interoperability. Barriers are incompatibilities of various kinds and at various enterprise levels. …. Developing interoperability means to develop knowledge and solutions to remove the incompatibilities."*

David Chen, D. Dassisti, M. and Tsalgatidou, A., Interoperability Knowledge Corpus, An intermediate Report, Deliverable DI.1, Workpackage DI (Domain of Interop-erability), INTEROP NoE, Nov. 25th 2005.

Interfaces recommended by the European Network of Excellence **INTEROP-NoE** and then **Interop V-Lab**.



Enterprise Interoperability Framework (Interop NoE & V-Lab)



Interoperability concerns

Interoperability approaches

Interoperability barriers

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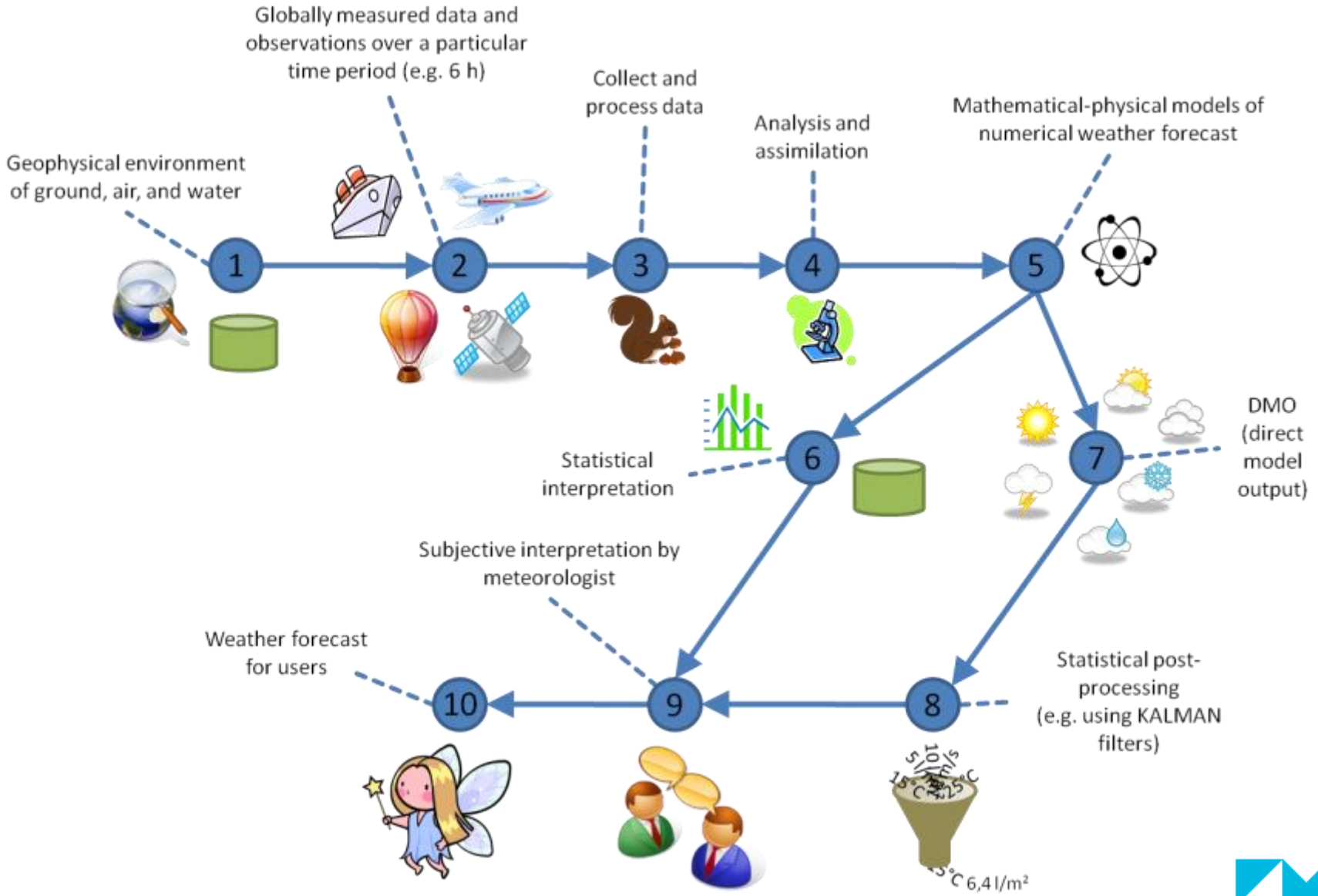
A need to orchestrate Data exchange in Workflows (Sequence, causality and Time)



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2. Interoperability -> Driving System Design and Implementation

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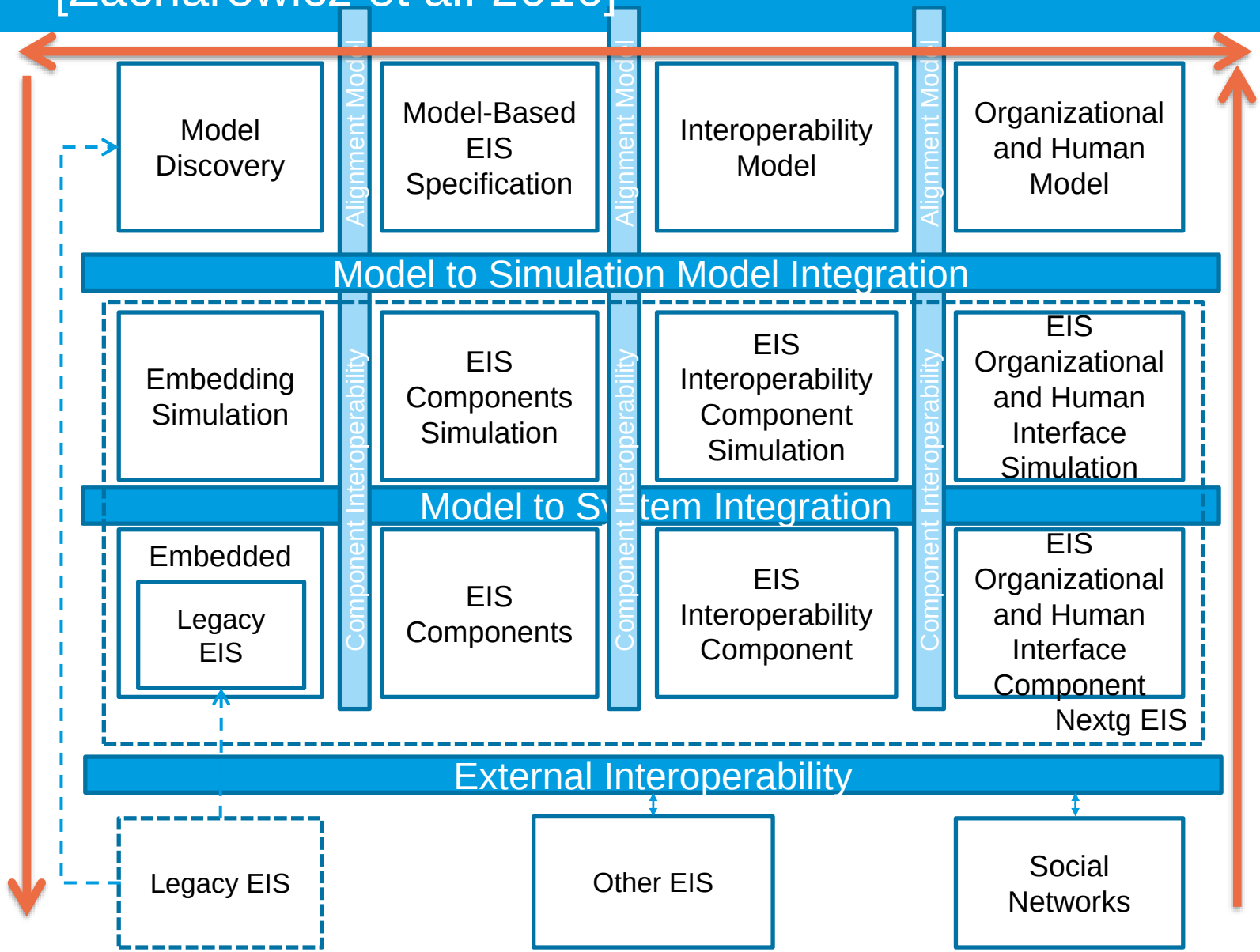
2.0 Model Based Methodology [Zacharewicz et al. 2016]



Gregory Zacharewicz, Saikou Diallo, Yves Ducq, Carlos Agostinho, Ricardo Jardim-Goncalves, et al..

Model-based approaches for interoperability of next generation enterprise information systems: stateof the art and future challenges. Information Systems and E-Business Management,

Springer Verlag,2016, 10.1007/s10257-016-0317-8. hal-01321032

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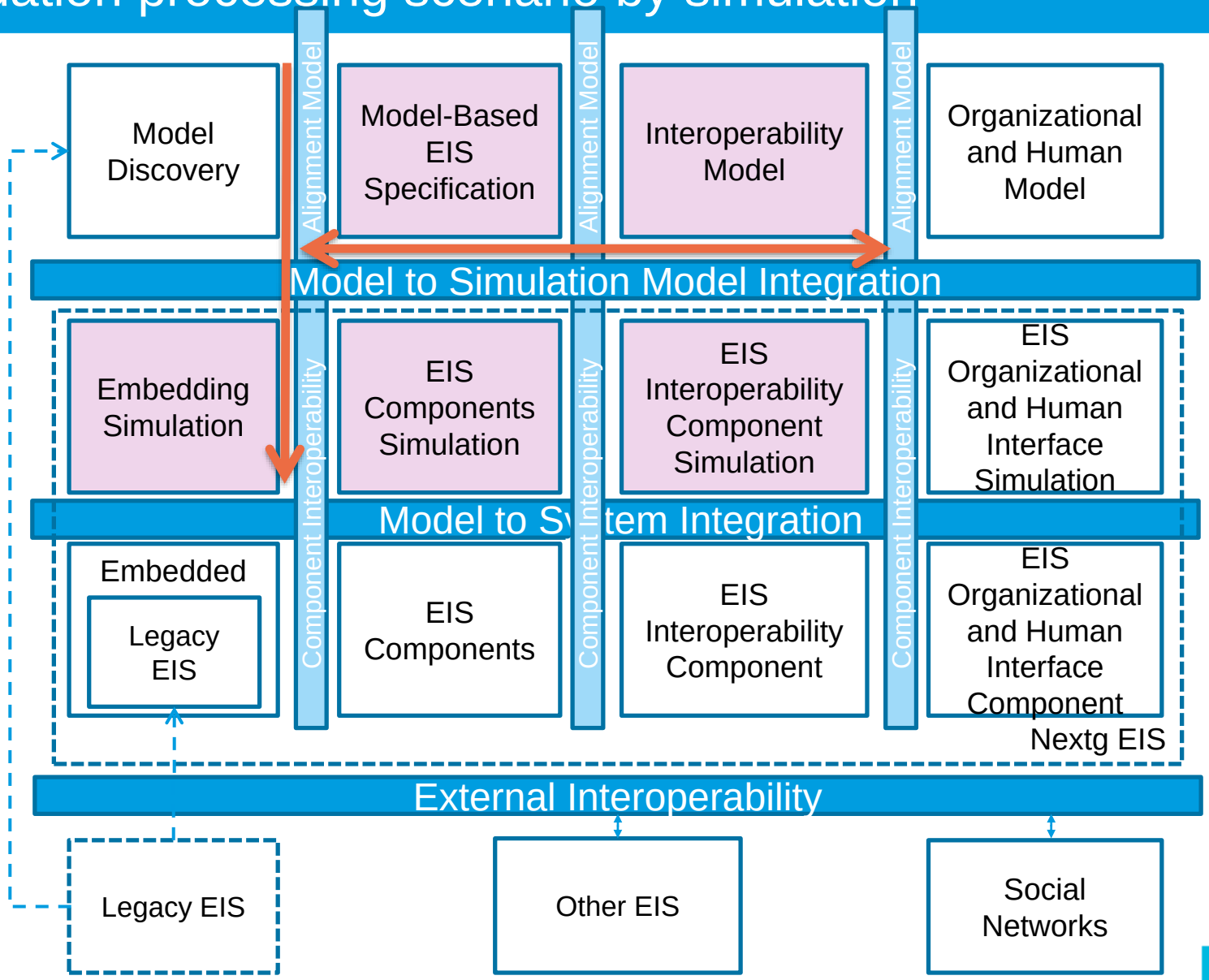
2.1 Horizontal / Vertical Down Interoperability Models for validation processing scenario by simulation

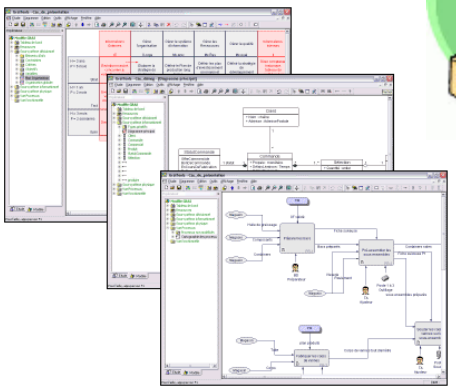


2.1 Horizontal / Vertical Down Interoperability Models for validation processing scenario by simulation
Thesis Hassan Bazoun (Co-supervised with Yves Ducq)

Conceptual Models

(Semi Formal Models)

"Business professional views "



ATL or XSLT Model Transformation and enrichment

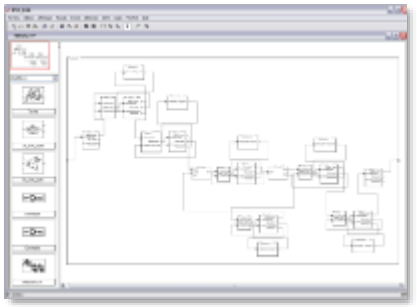
Simulation Models

DEVS/HLA Model Editor & Simulator

BPMN Model

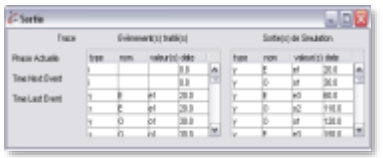
process Workflow XML Specification or other

DEVS XML specification



Checking DTD structure

Checking DTD structure



Use of results to display and animate BPMN model for non-expert

Simualtion results

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Syntactic Interoperability with Distributed Simulation

➔Simulation of Heterogeneous component:

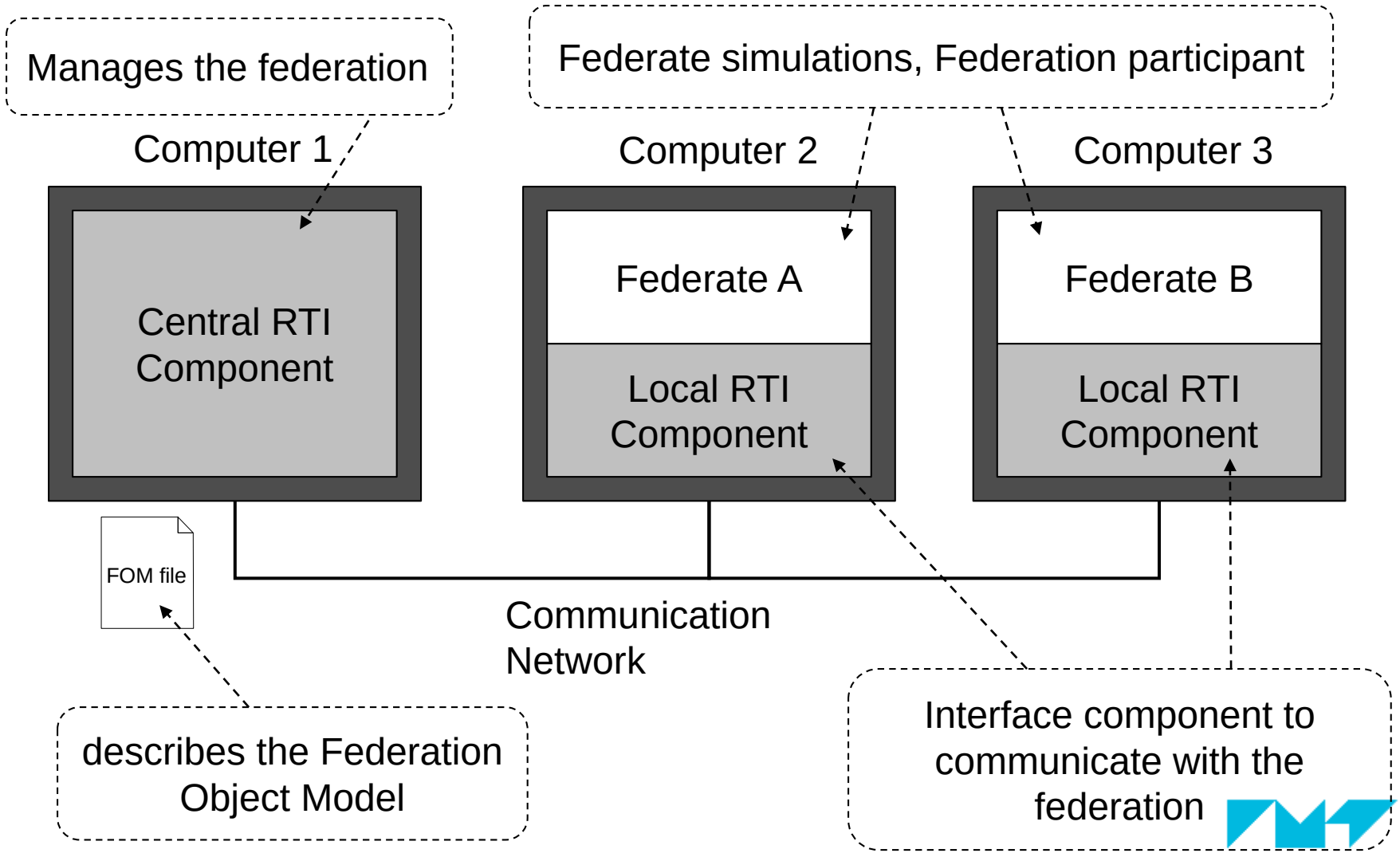
- Distributed Simulation
- Co-Simulation

➔ Syntactic Interoperability with Distributed Simulation and HLA Standard

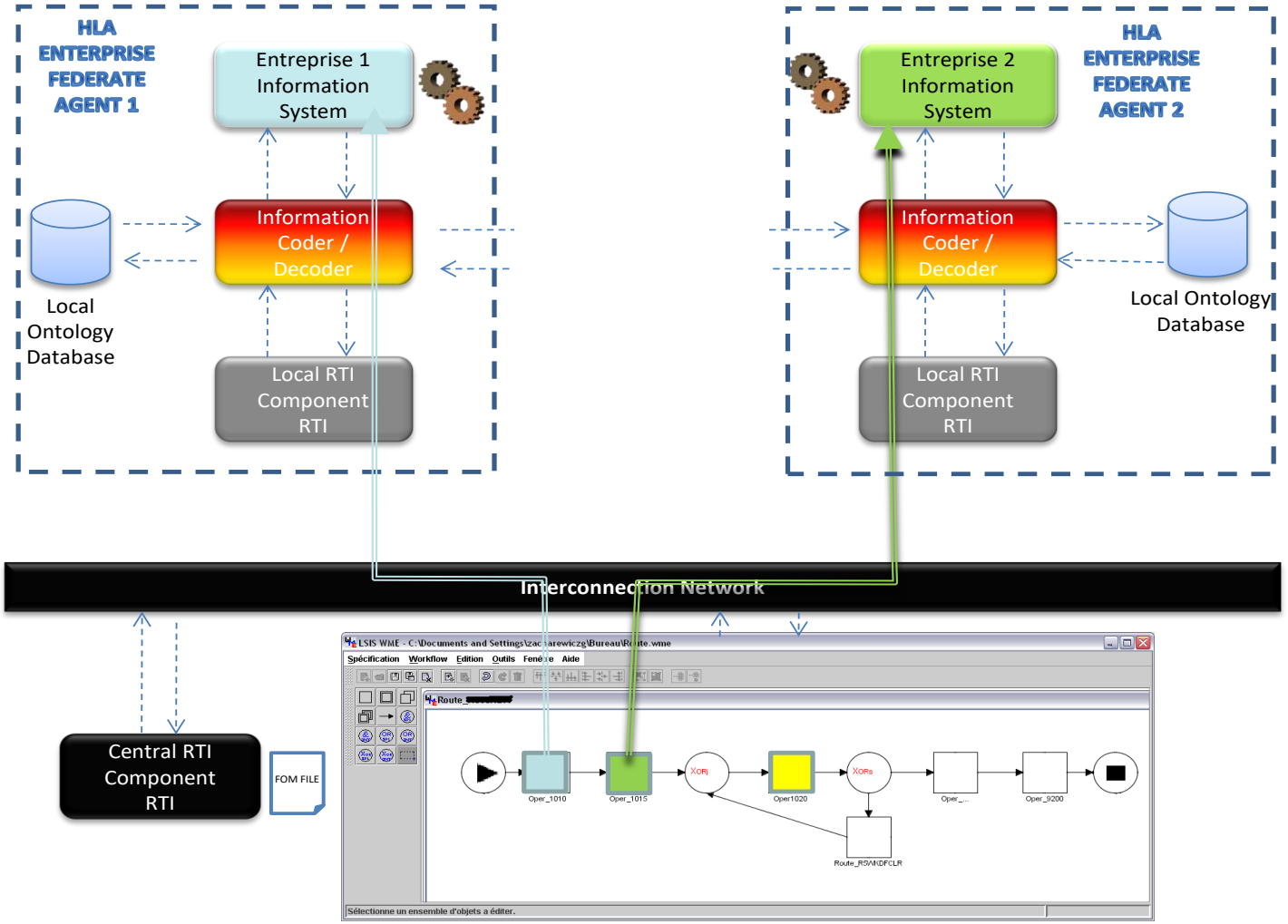
- The High Level Architecture (HLA) is a software architecture **specification**.
- The atomic simulations inserted in a global distributed simulation respecting HLA are named **federates** participating in a **federation**.
- **Standardized** by SISO and maintained by IEEE

- HLA enables reuse and interoperability:
  - **Connect** without full re-coding (embedded with adaptor).
  - Interoperability and **Time Management (conservative and optimistic)** of components in a global distributed simulation.

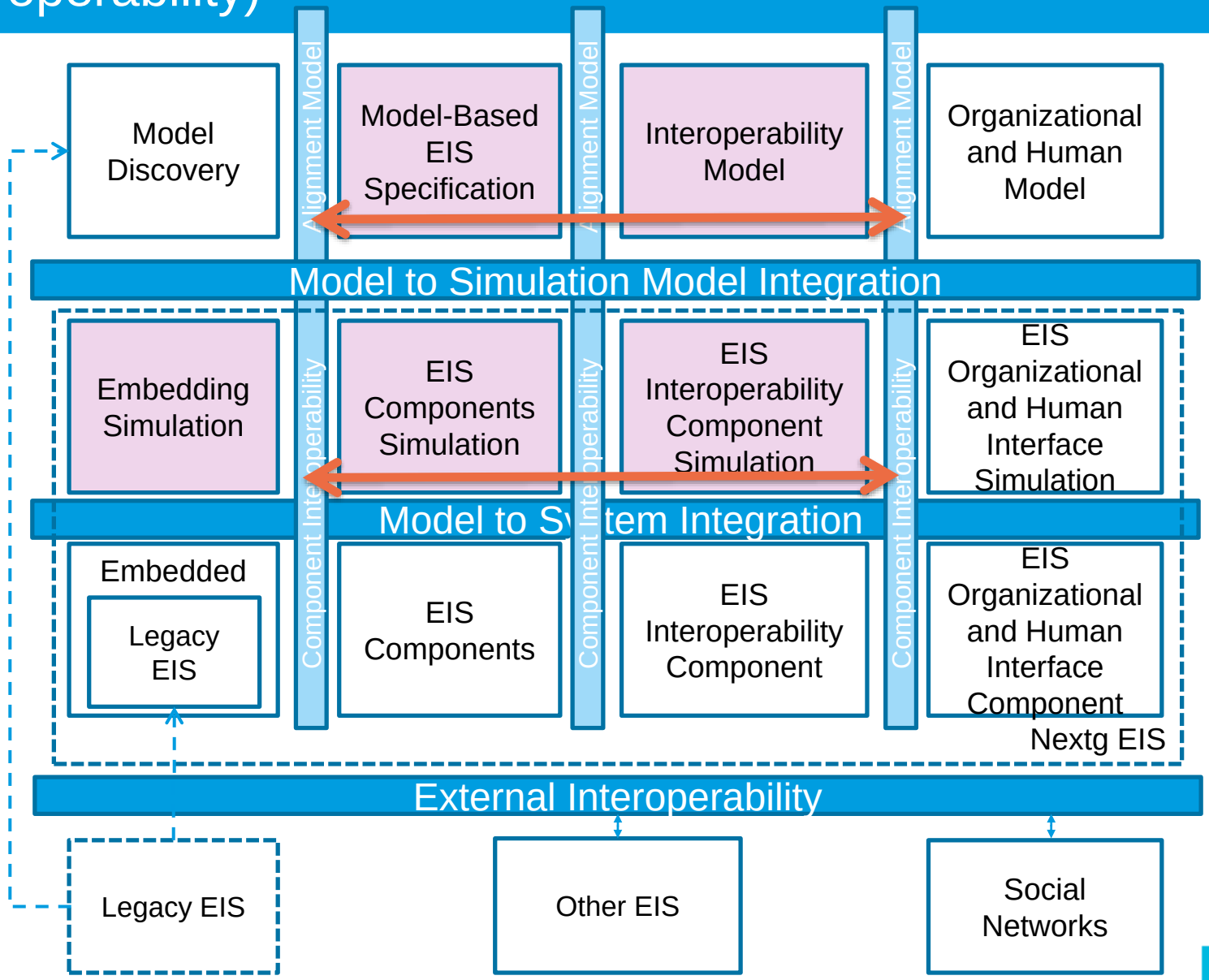
Syntactic Interoperability HLA components



Implementation of Enterprise Information System Simulation

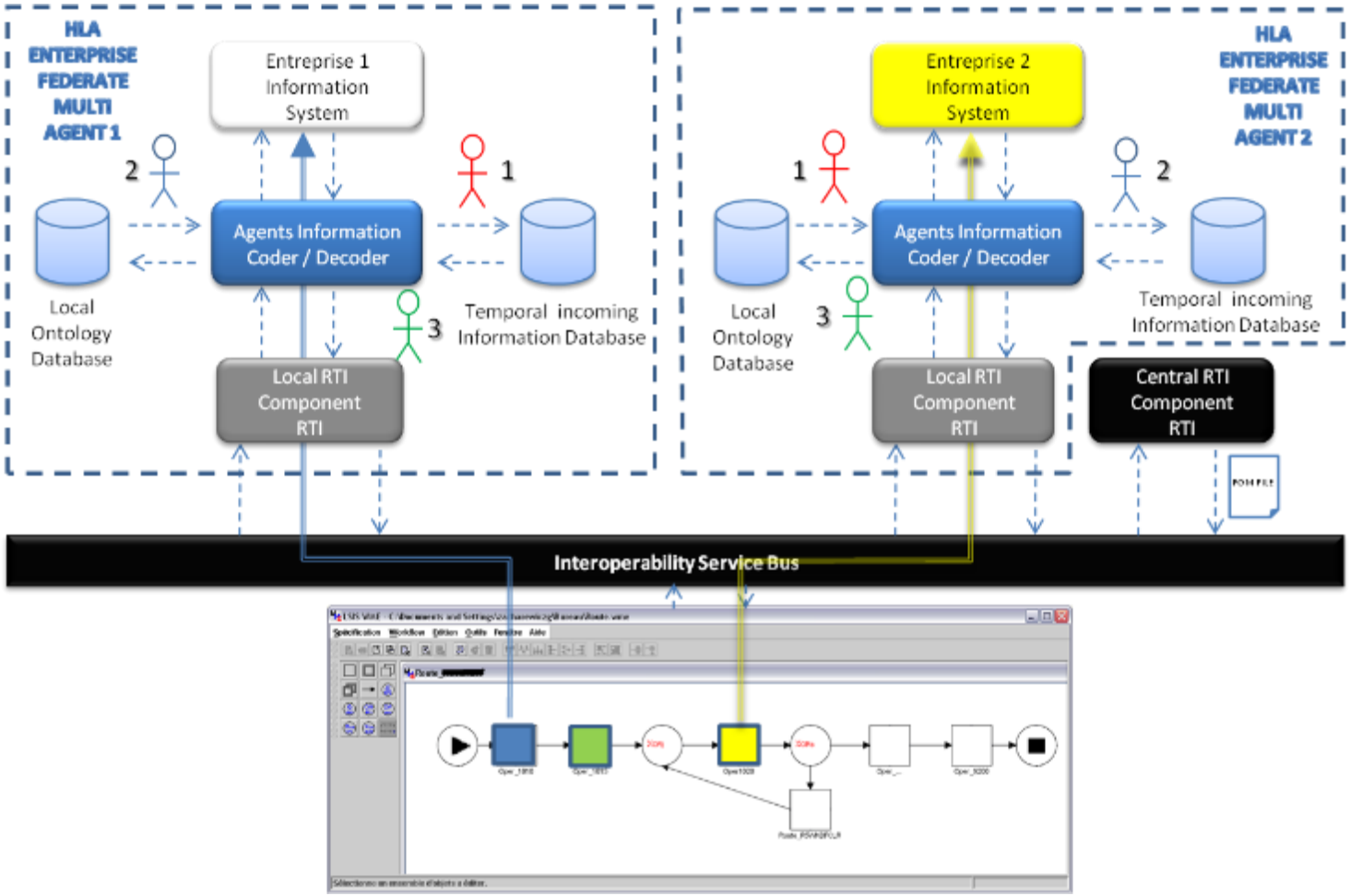


2.2 Model Matching Approaches (Horizontal Semantic Interoperability)



Purpose: Data Exchange Platform by Federation of Agents + HLA + Ontology

Short Lived Ontology



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Horizontal / Vertical Down Interoperability
Ontology Matching Alignment

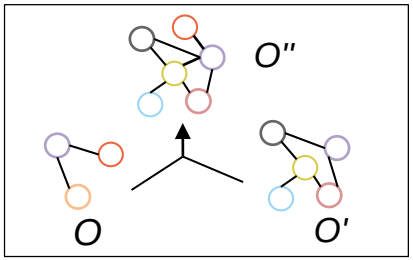
➔ Models and Data Matching

- A framework for **unifying ontology-based semantic similarity measures**
- The semantic measures library and toolkit: fast computation of semantic similarity and relatedness **using domain ontologies**.

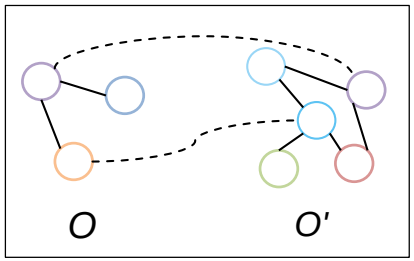
➔ "Semantic Matching" Model **Transformation Method**

- Comparing concepts in a common repository (Metamodelling, Ontologies)
- Semantic + Syntactic + Structural Distance Calculation Concept Matching

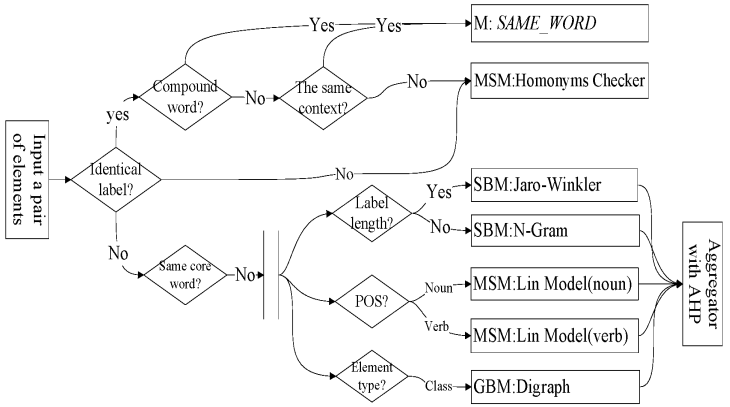
- **Merging representations (a) or Alignement (b) (Weak, Temporary)**
- **Assisted model transformation process**



(a) Merge / integration



(b) Alignment



Analytic Hierarchy Process

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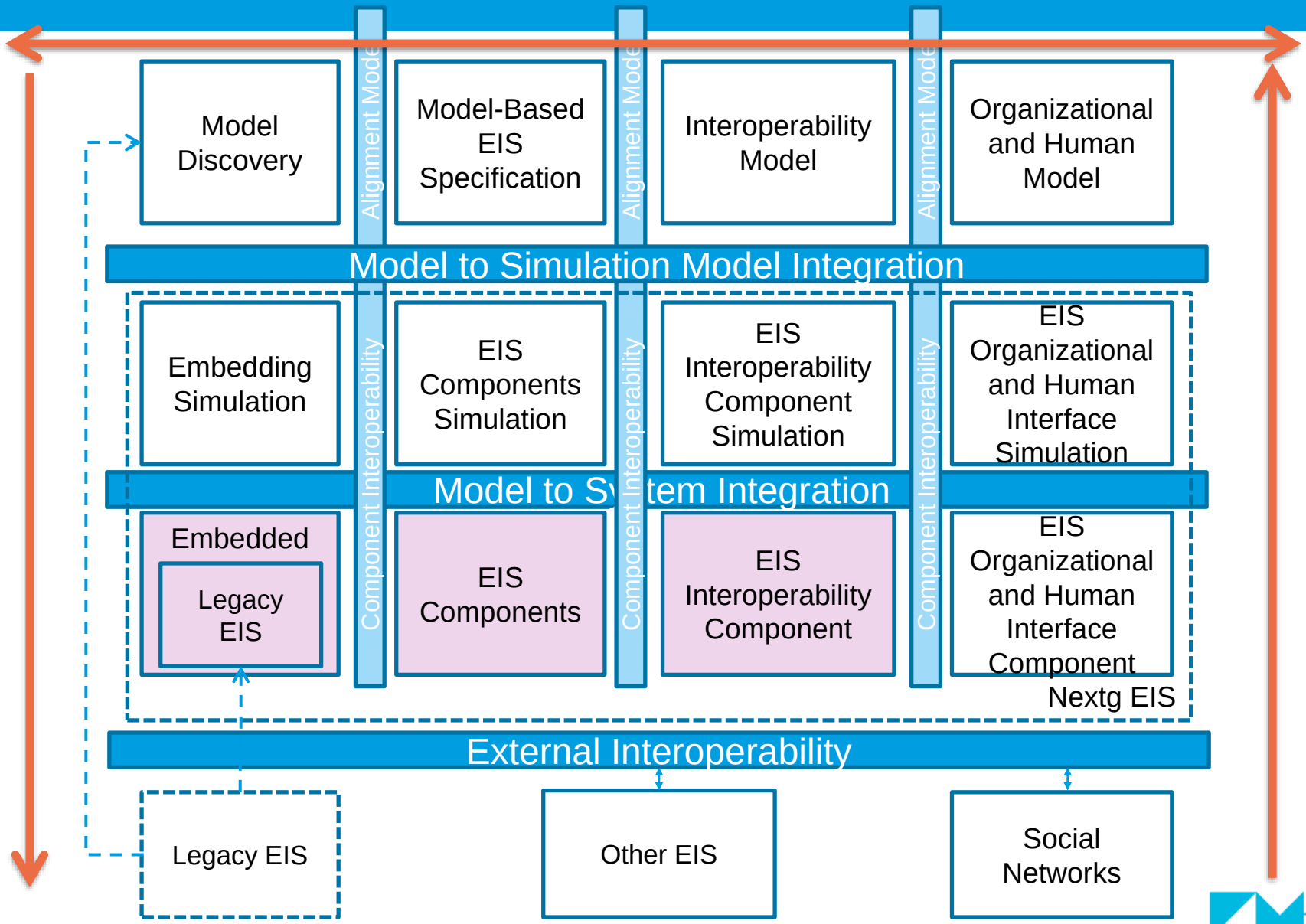
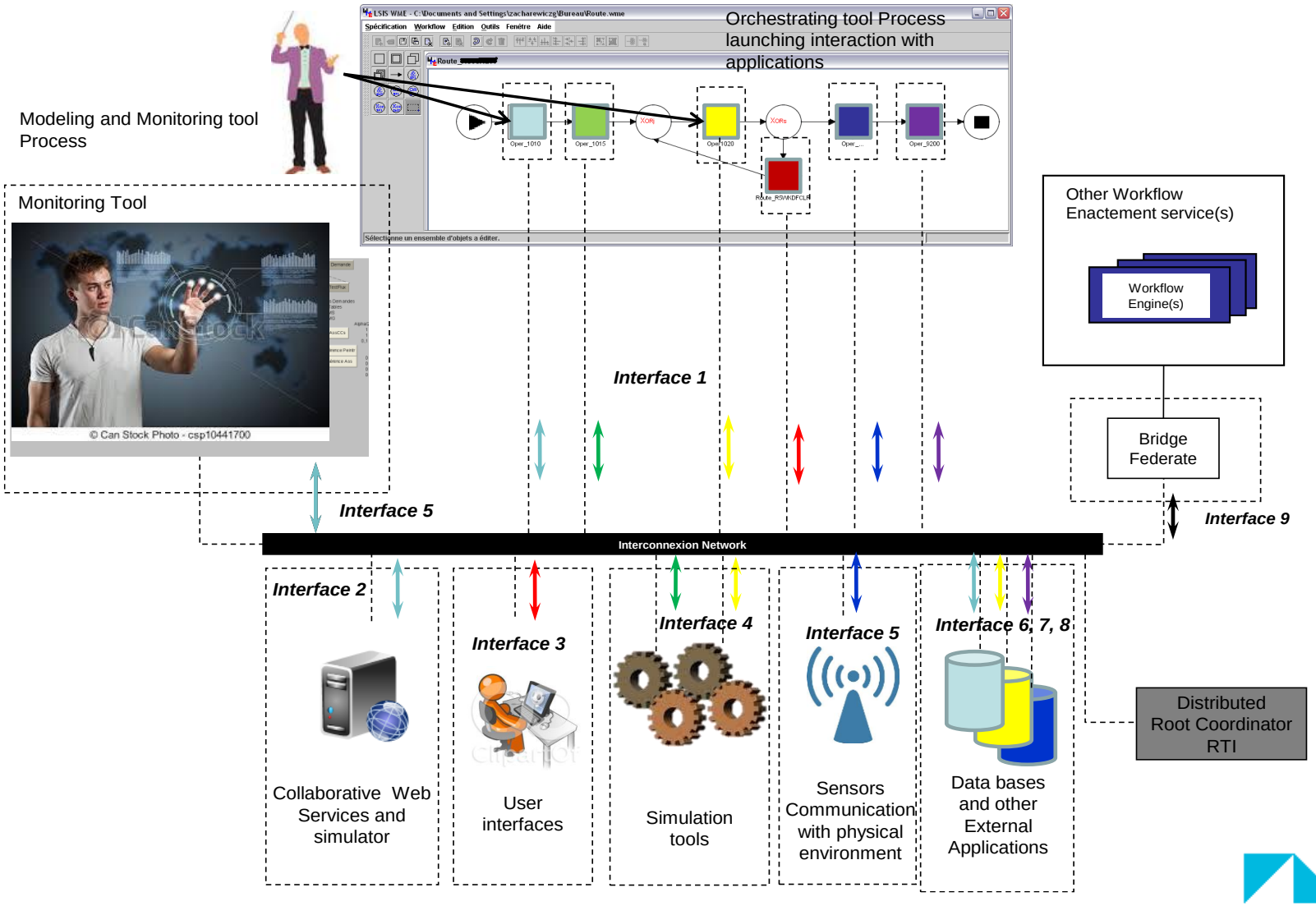
2.3 Interoperability at Execution Time



Integration Federation Objective: Definition of "Systems of Systems"



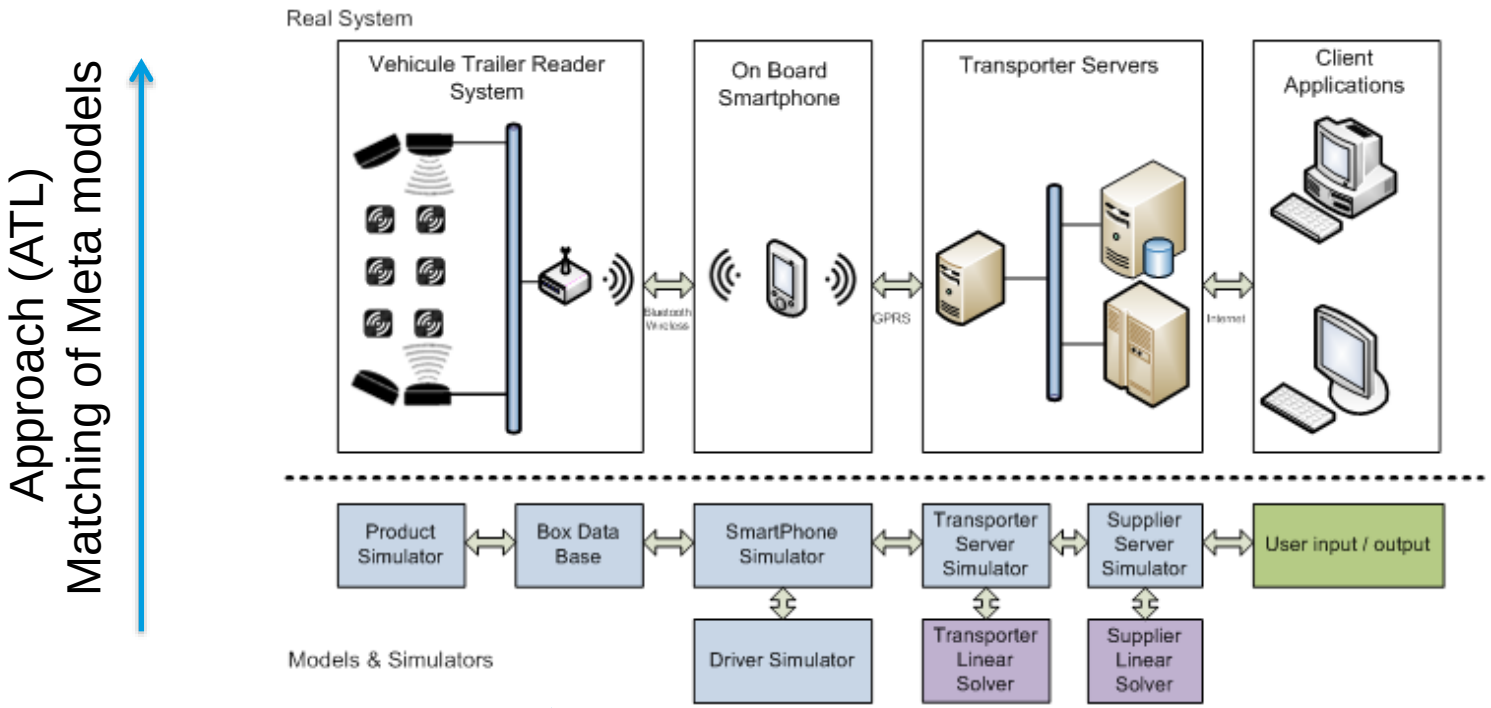
Execution Level Horizontal Interoperability between **M&S** and **Cyber-Physical Systems / Digital Twins**

➔ Transformation and Coupling Software Models with Physical Systems

- *Component Interoperability (**Internet of Things**), Execution and Distributed Simulation (**HLA**) Virtual/Real Coupling*
- *Object Directed Approach*

➔ Ontologies-Driven Data and Model Transformation and Performance Monitoring

- *How Can **Ontologies** can give a real time understanding.*



Intelligent Transportation System with Digital Twin (Ex. ANR PRODIGE)

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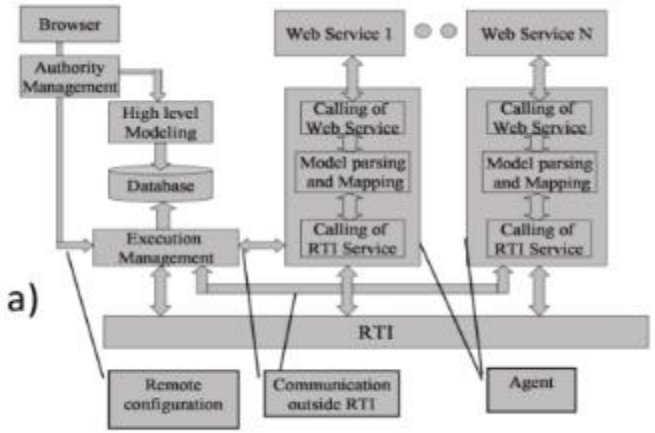
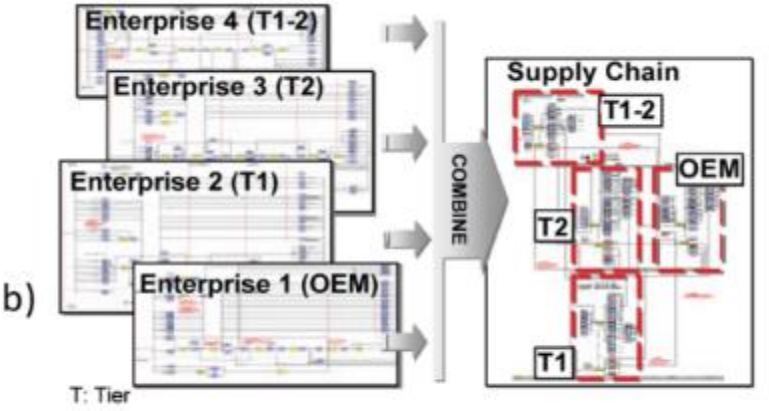
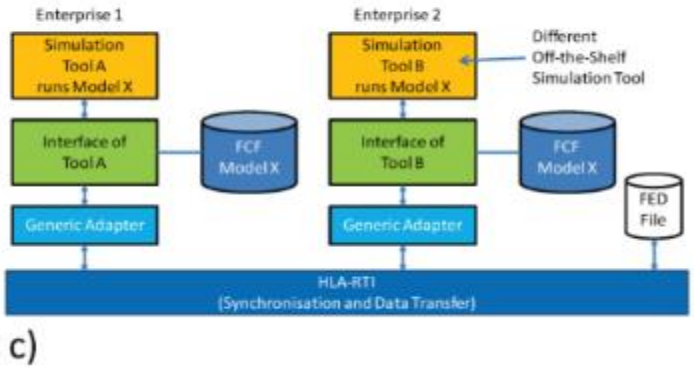
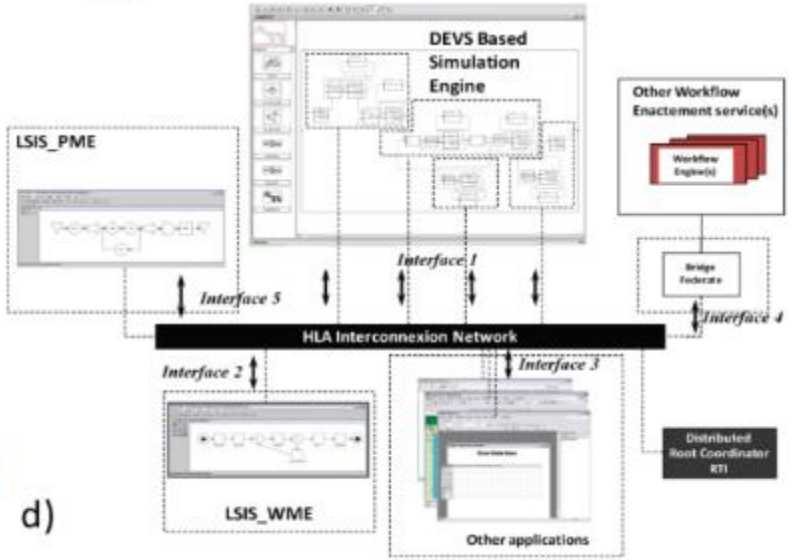
Evaluation of different HLA based Interoperability Platforms: Reaching “Full Interoperability” ?









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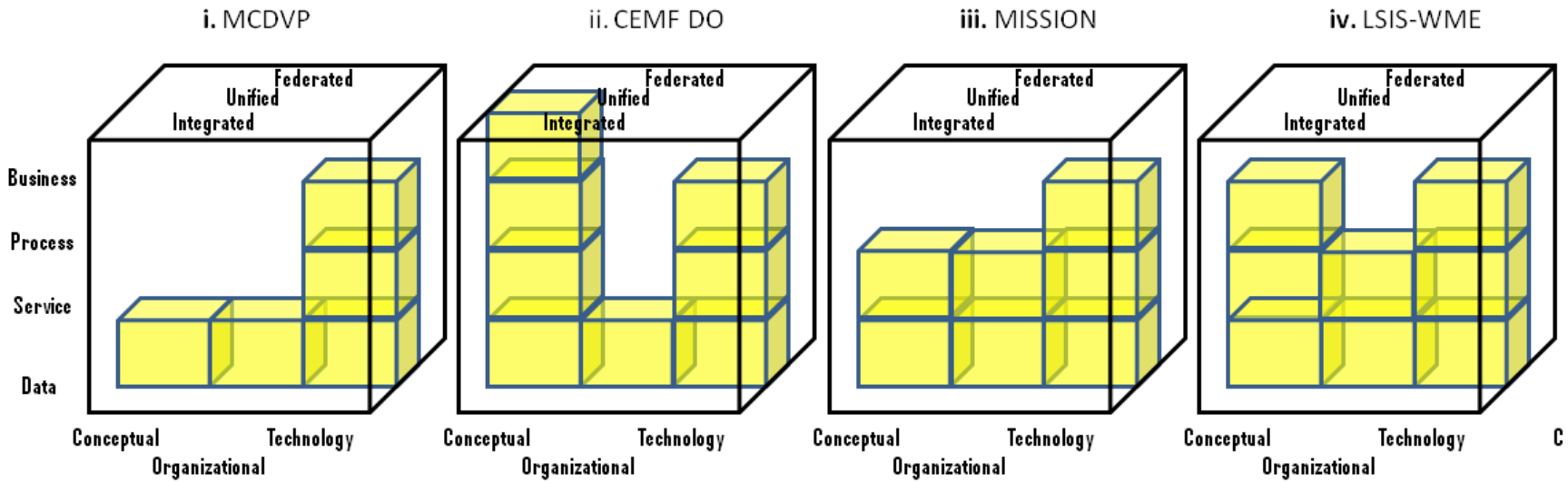
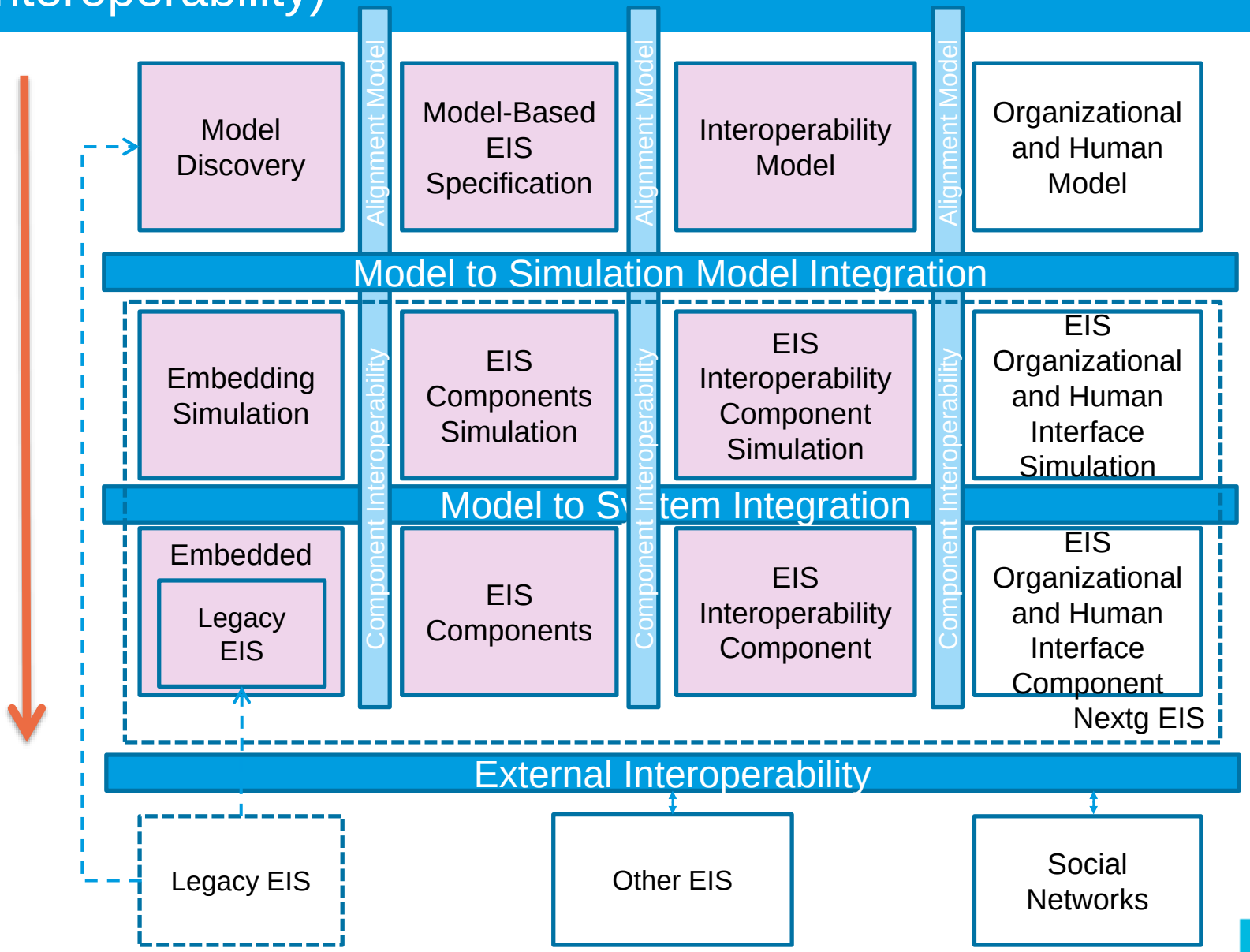
Comparison of different HLA Compliant Interoperability Platforms regarding Interop « Cube »

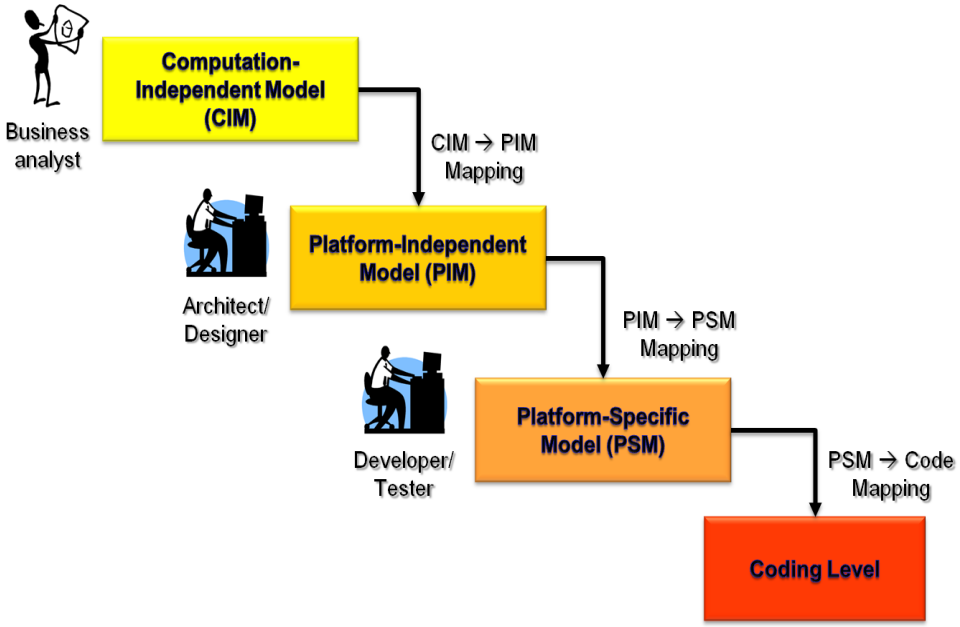


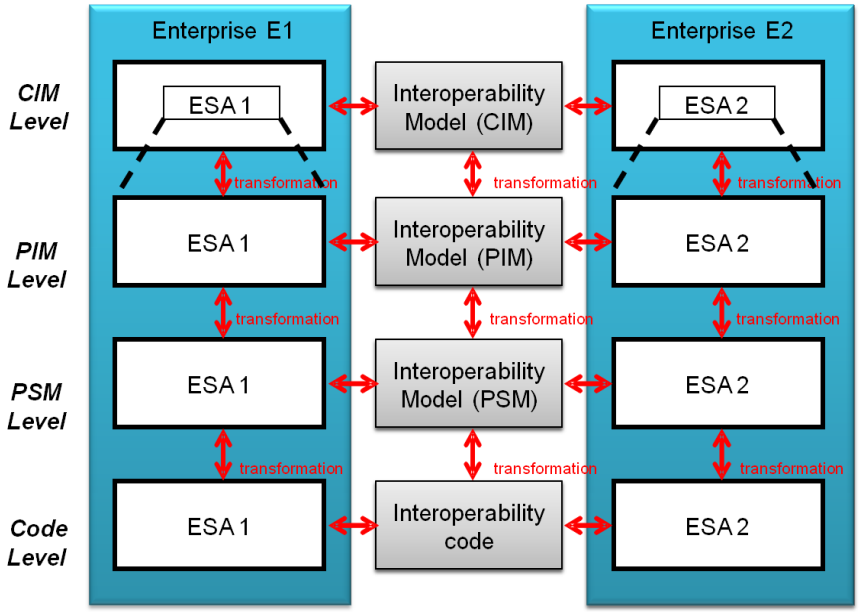
- **None Platform is covering correctly "federated interoperability“** concept in the definition of the Interop V-Lab,
- Maybe because they are **missing/losing some of the objectives** in the **path from Conceptual Models to System Development,**
- **Organizational** aspects are not well considered

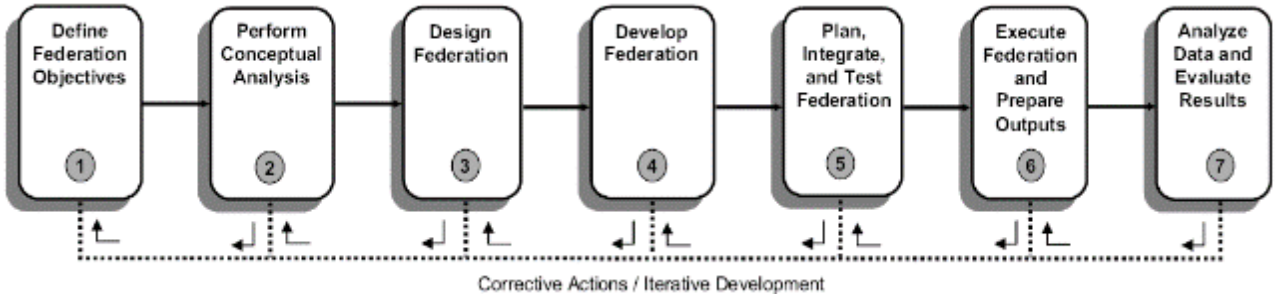
2.4 Model Driven Approaches (Driving down Vertical Interoperability)



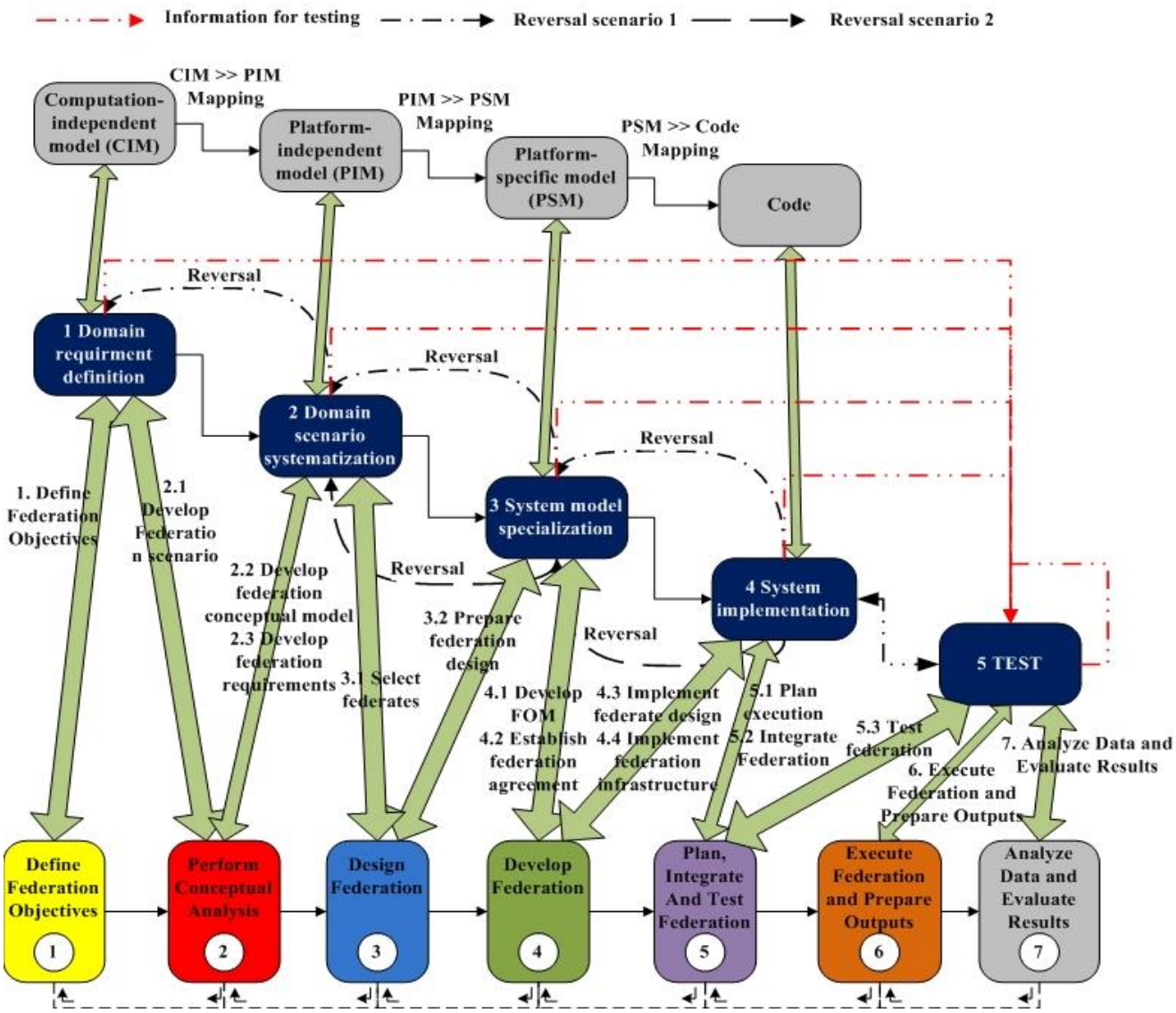
Methodologies or Development Cycle Led, Driven or accompanied by models: MDA/ MDI/ FEDEP







Zhiying TU's New Models Transformation Method + Reverse Thesis (Co-supervised with David Chen) (2013)



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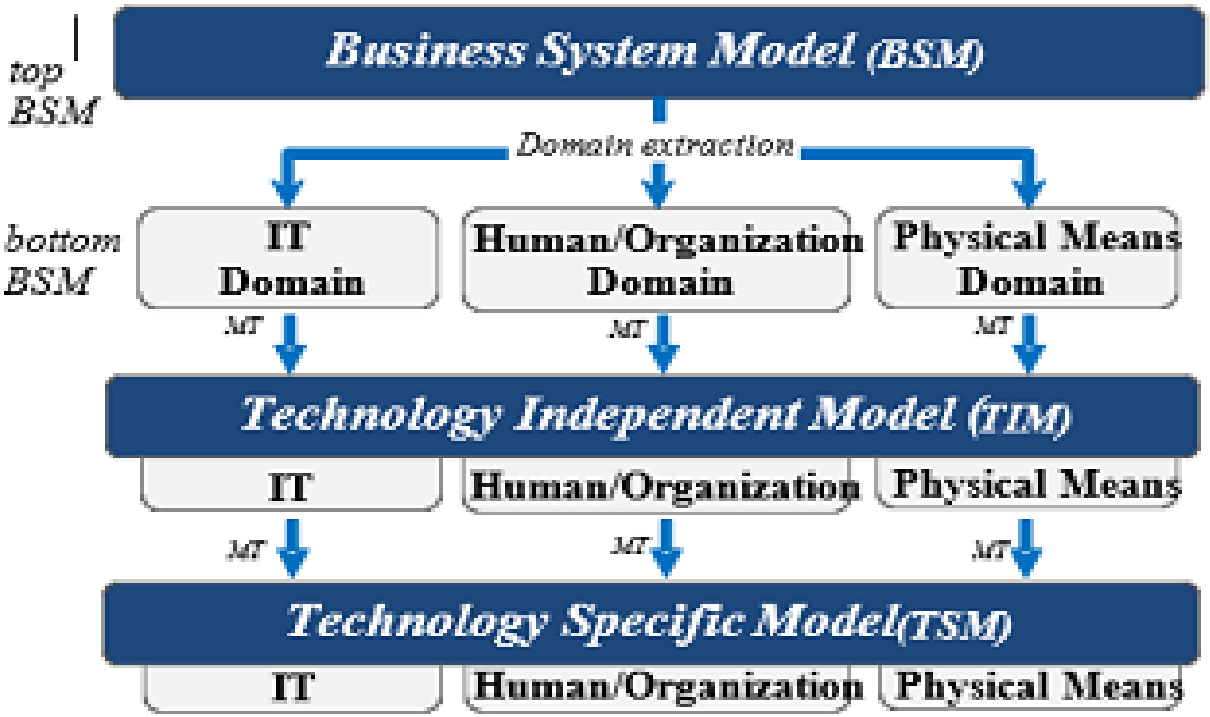
FP7 Project Manufacturing SErvice Ecosystem (MSEE) MDSEA Approach (2015)

Model Driven System Engineering Architecture (MDSEA)



MT: Model Transformation

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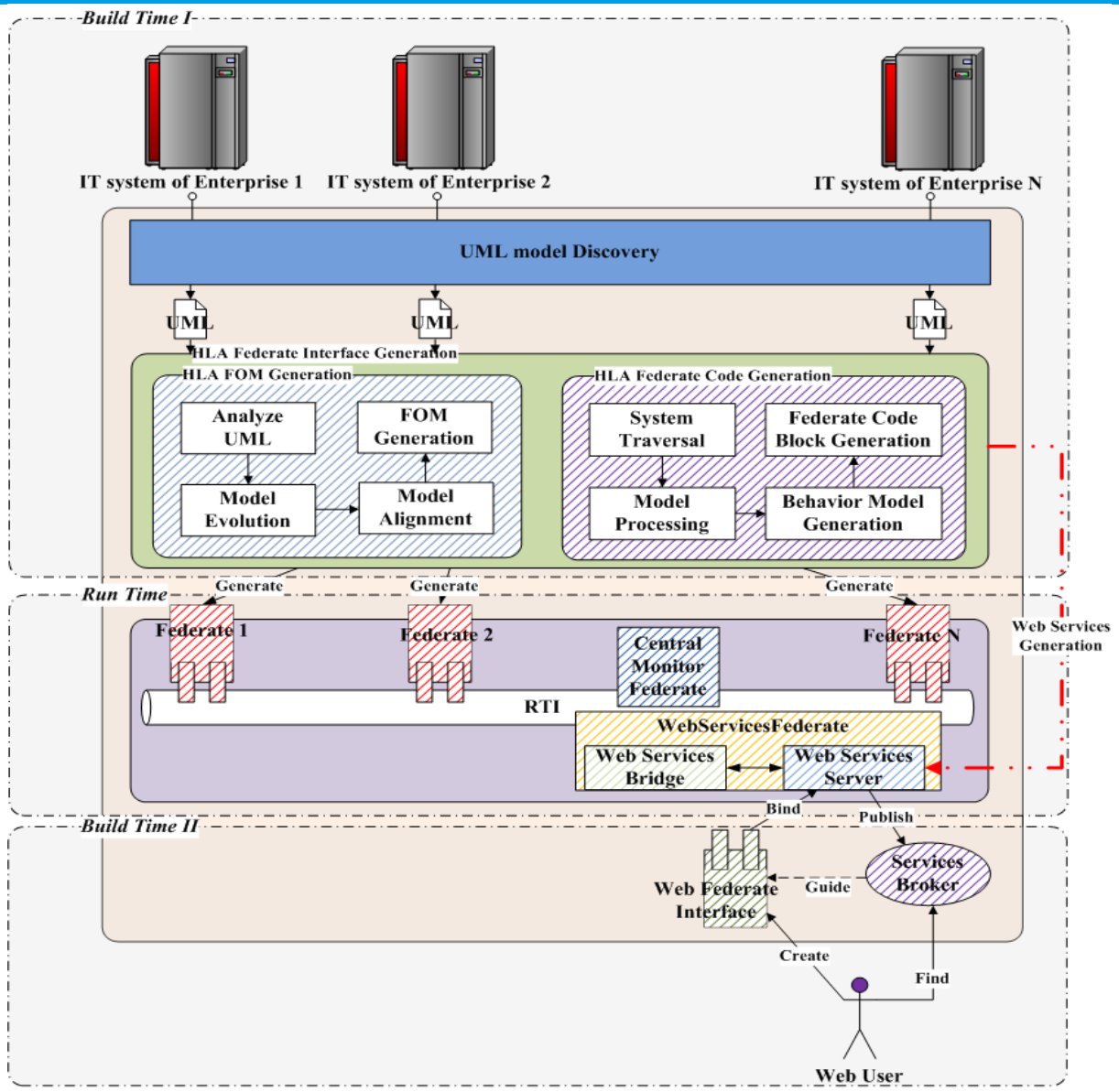
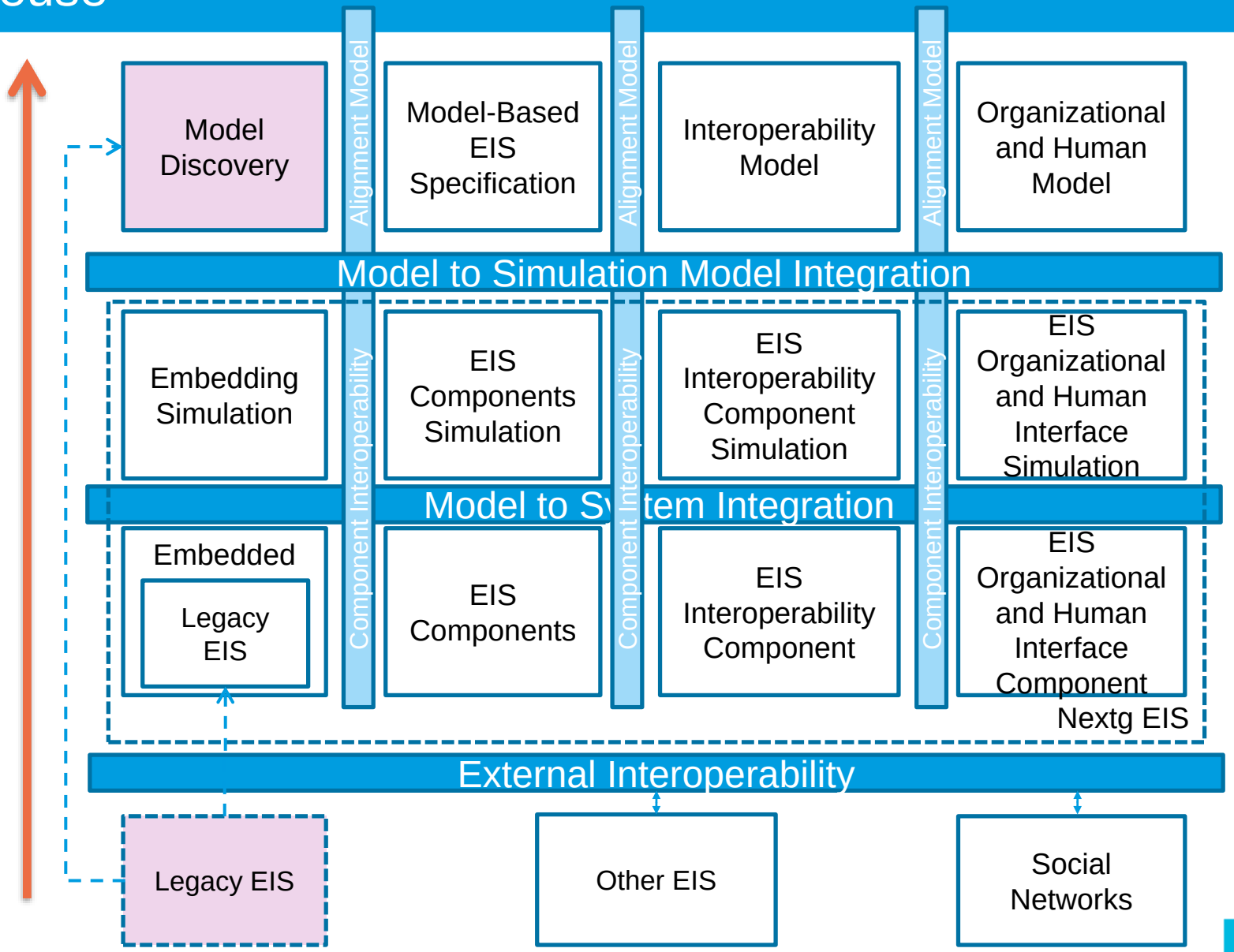
Model driven and HLA based Reverse Engineering Tool Architecture



- ✓ Analysis of the existing,
- ✓ Discovery of models,
- ✓ Encapsulation of “legacy" systems,
- ✓ Fast execution using the HLA standard and web services call

2.5 Model Discovery with Traces and data Mining for better Reuse

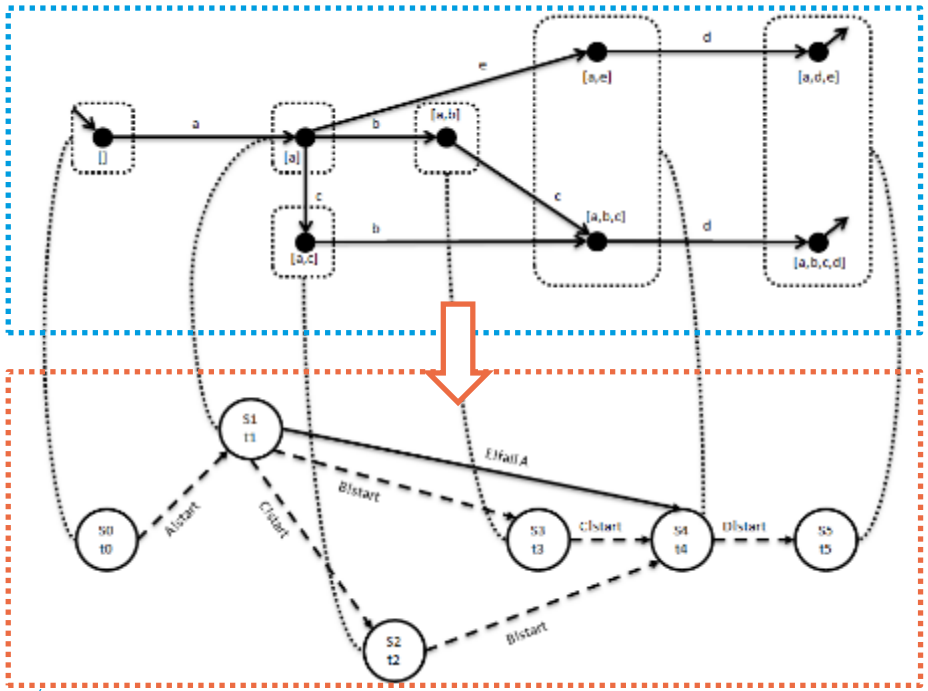


Bottom-up Interoperability Behavior Model Discovery

- **Systems Re-engineering by Mining**
  - ***Reverse Engineering Feature Models from Software Configurations***
  - ***Using Van Der Aalst Works (Process Mining PROMT Tool)***

- Integration into the team around the Discovery of **a Behaviour Model**
  - ***DEVS based Process Mining* (Discovery of Behavioural Model) [2015]**

Event log
based on the XES
standard



Model of Behaviour:

Transition Systems (TS)

Discrete Event Models (DEVS)

Notion of time:
Lifespan, Dated messages

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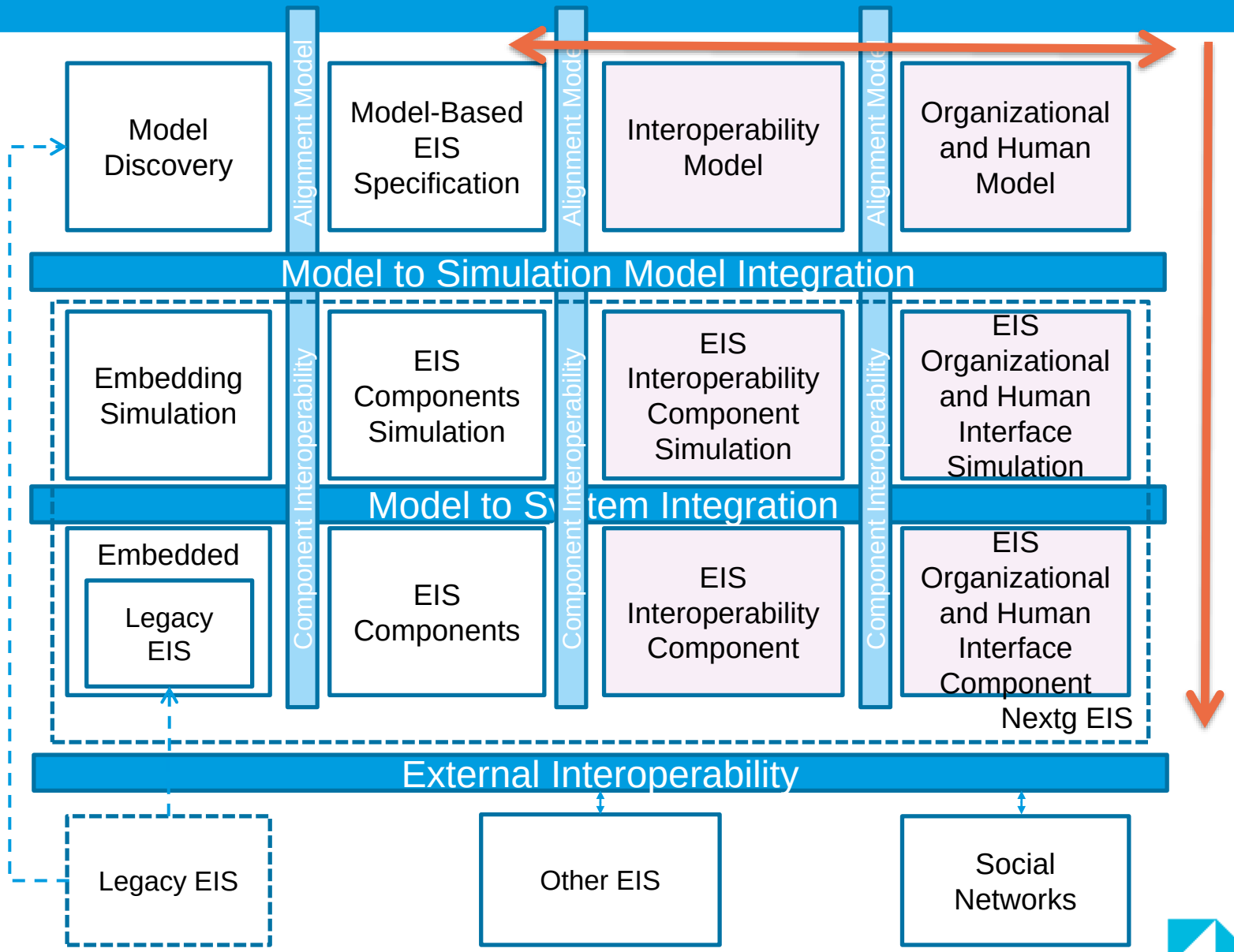
2.6 Organizational & Social Interoperability



Organizational & Social Interoperability

Information, communication and social sciences study the various way of information and communication exchange involving human, focusing in particular on**:**

- ➔ **Mediation between Human/Human and Human/Machine,**
- ➔ **Design process (not fully formalized process),**
- ➔ **Mechanism of Human Information Production,**
- ➔ **Perception, Interpretation of information**
- ➔ **Deal with various representation of concepts, View points**

Better Adoption of sociotechnical devices and innovation.

Human and Organizational Interoperability: Work on modelling a Multidimensional Social Network

➔ Network and behaviour dynamics

How information spreads in a Social Network, and affects individuals

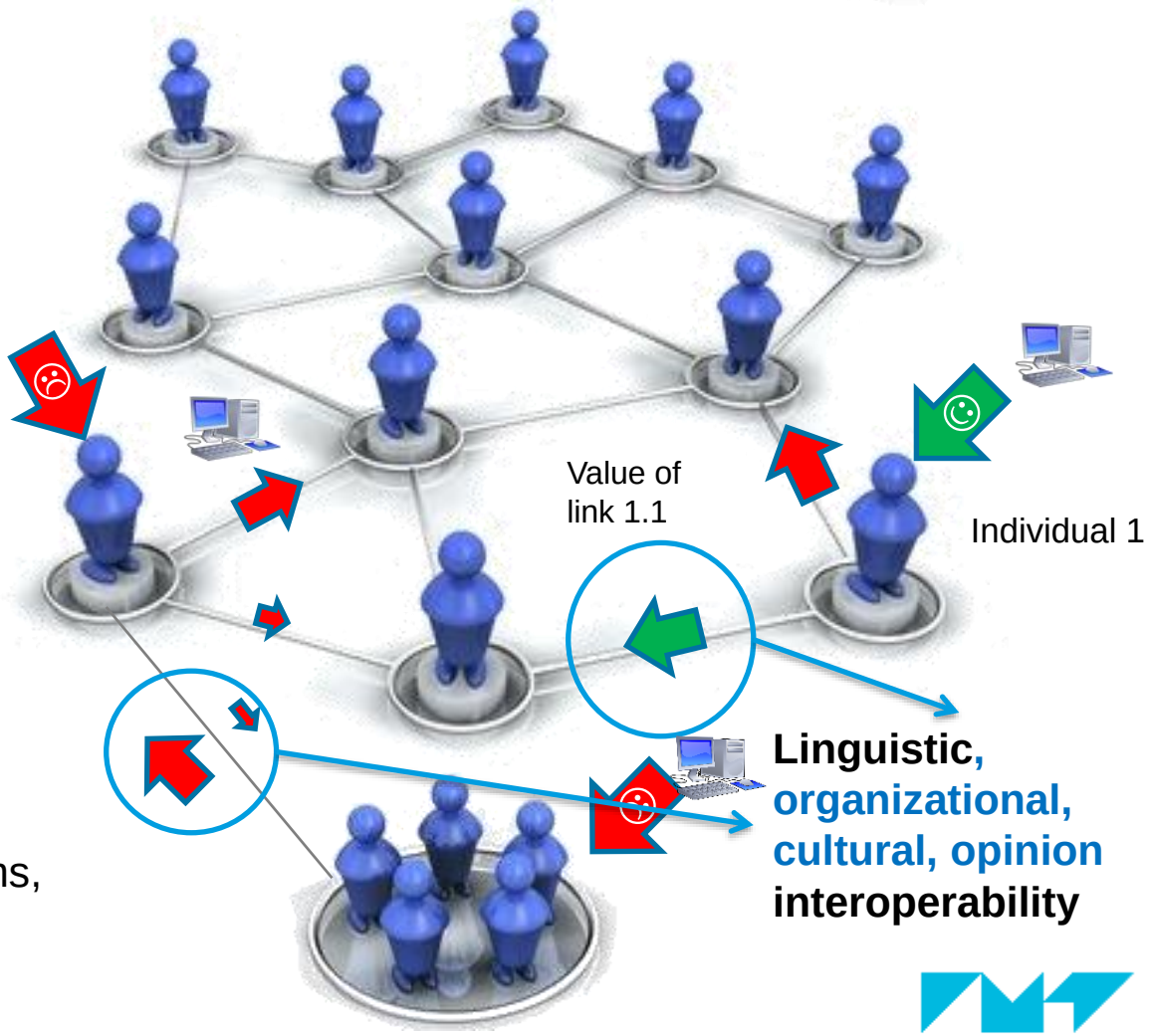
Phenomenon to be Modelled

- Models of information behaviour (function of message, transmitter, network)
- Models for mitigating influence based on the value of the link (weighting) of the message (strength, content of the message)

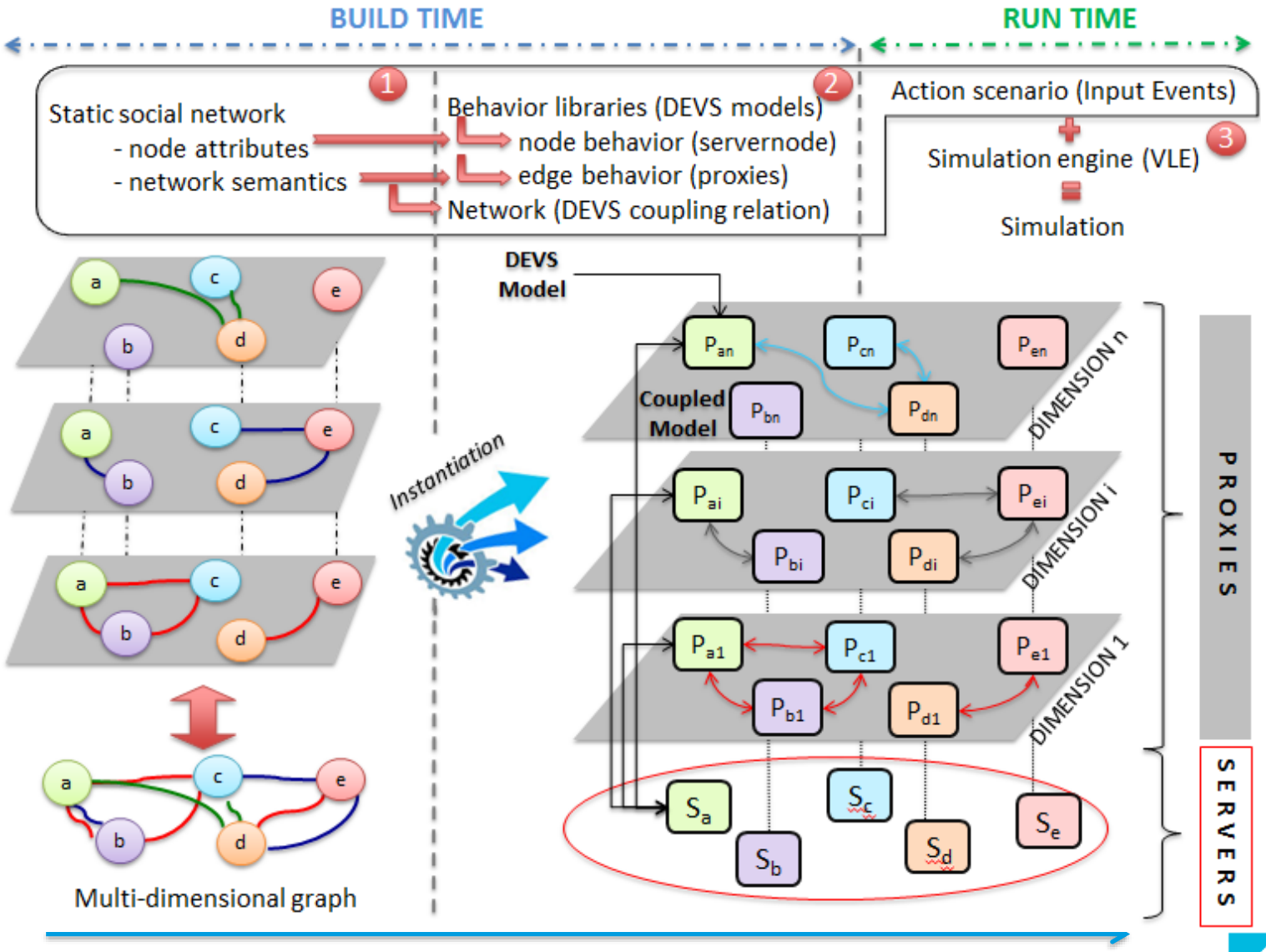
Usefulness

Observation of distribution mechanisms, coverage, impact of content, media

Multidimensional Networks

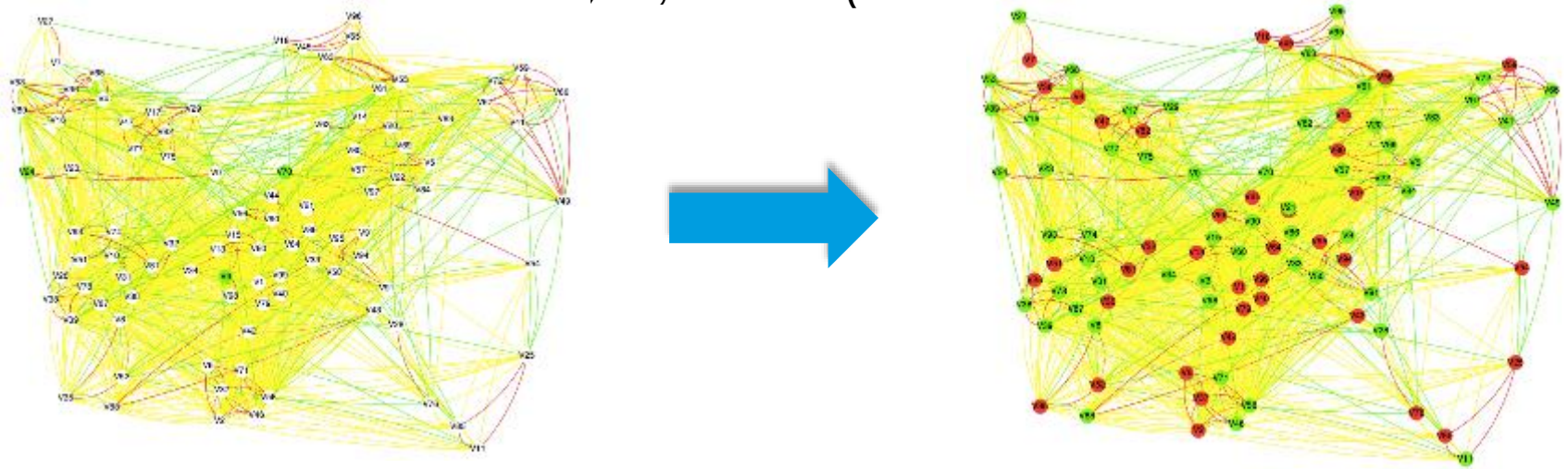


Modelling of individuals and networks - Simulation



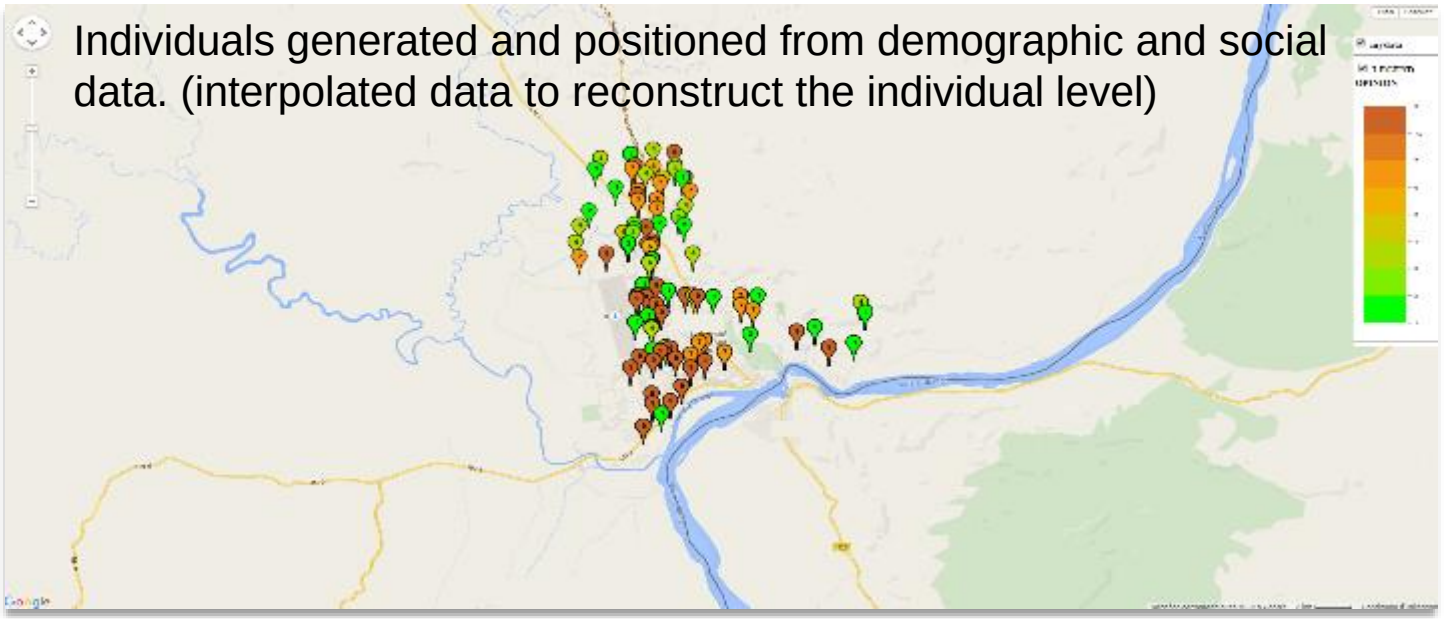
Results of an Experiment in Disseminating Information

- **Simulation Results: Observation of Change of Opinion**
- **(Individuals affected (or not) by a message and evolution of their states)**
  - ***Impact of the network structure*** *(Centrality, Scale-free, Small-world, etc.)*
  - ***Opinion dynamics: function of the sender's opinion****, strength of the message, function of social pressure (number of messages received), function of temporality (erosion of effects, correct phasing)*
  - ***Validation****: Sensitivity analysis, ANOVA (Variance) test, Covariance*



Initial Opinion of Individuals/ Final after Message Delivery

Experimentation: Results displayed in a GIS (Google Map)



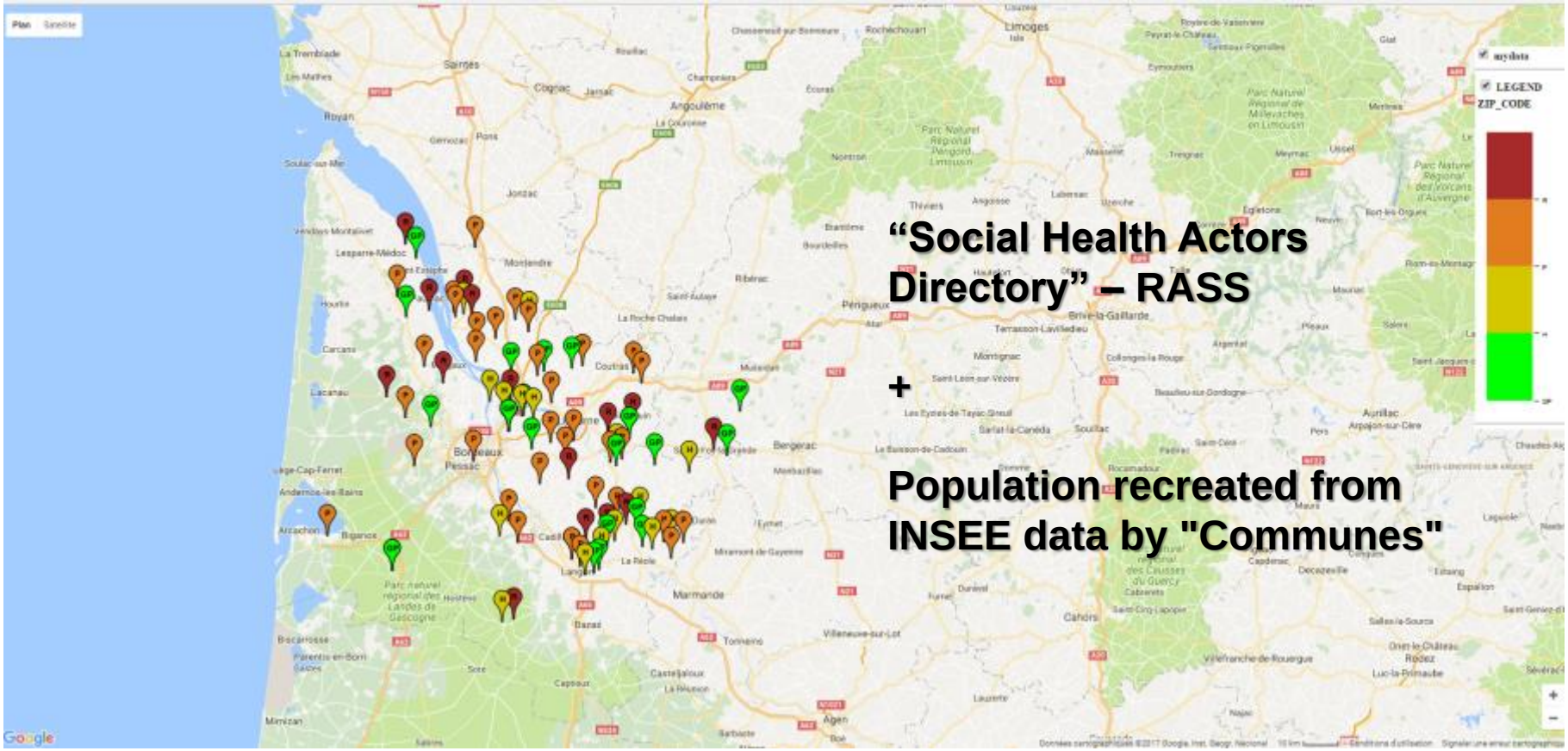
Simulation Results: Change Observation, Indicator Monitoring:

Evolution of the status of individuals based on received messages + territory position (Opinion of information, Physiological need, Psychological, Health)

Objective Targeting Models, Maximizing an effect (e.g. position of a source of information), Resource configuration, network structuring, synchronization

Transposed to risk management with Univ. Carleton and Valladolid

Region Nouvelle Aquitaine: Rural Care path (desertification)



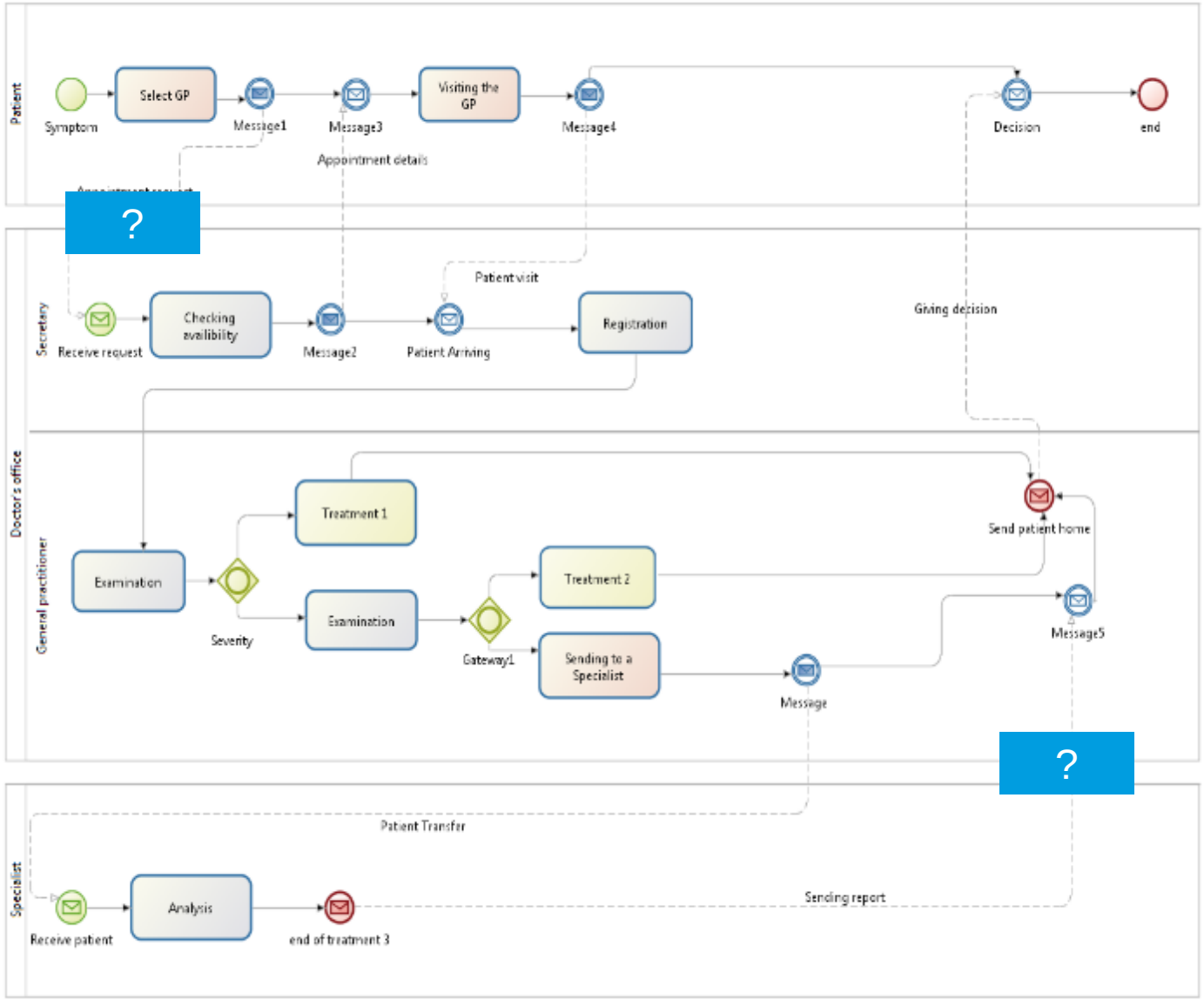
Rural Healthcare Management in Dordogne

- Location of different Municipalities:
- From major Cities to Villages
- Population Generator: Inhabitants
- Healthcare Services (GP, Specialist, Radiology…) professionnal repository

Number of inhabitants of the selected communes of the Dordogne department:

Name of the municipality	Saint-Priest-les-Fougères	Saint-Front-de Pradoux	Boulazac-Isle Manor	Périgueux
Number of inhabitants	383	1 170	10 104	31 540

Orchestrate Agent Steps: Care Path Workflow (Healthcare Management Rules from Medical Domain documents)



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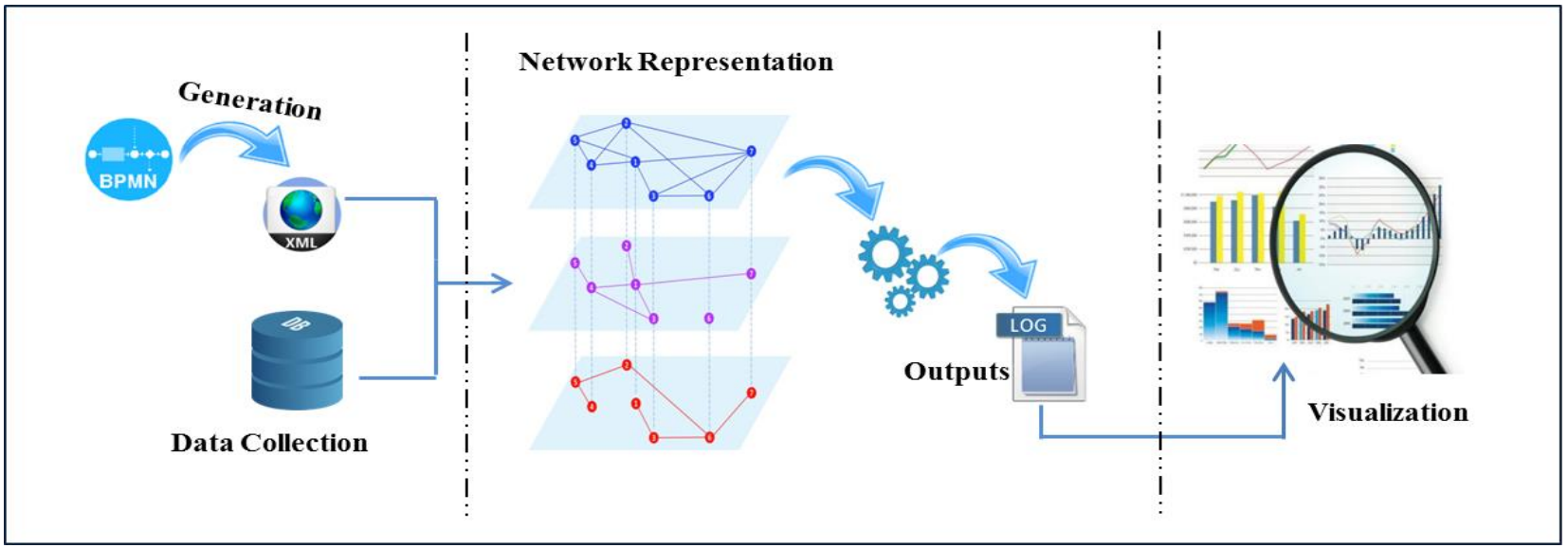
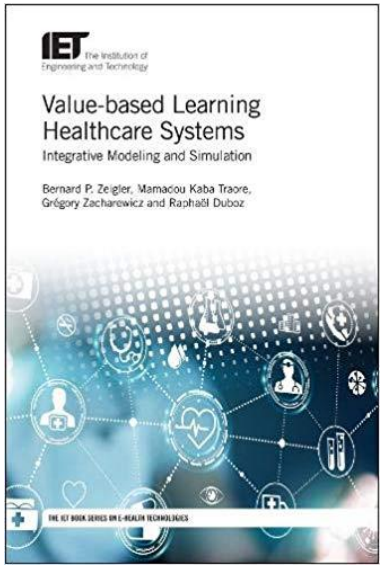
Model Driven Approach





Perspectives M&S Study of Health Policies with VMASC Prof Saikou Diallo

Governments are studying the development and implementation of **health policies to** reduce the percentage of overweight people that is increasing in **the world.**

Several modes of action are envisaged:

- **Resource and Infrastructure Policies**, such as changing building codes to move a parking lot a bit farther from a building.
- A **combination of food policies**, such as fiscal policies on health-impacting products, and ways to increase physical activity.
- Finally, **communication awareness campaigns** can be launched

While this last action may be effective, it is difficult to assess them **before they are actually implemented**.

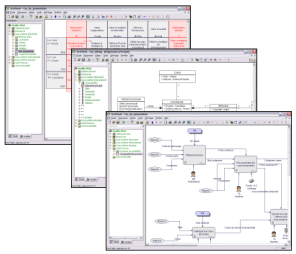
This project draws on the ways in which social media (networks) information **is** disseminated to see how to maximize the impact of campaigns.

It proposes an agent-based modelling.

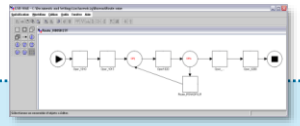
Enlarging the Overview of Interoperability contributions

Conceptual Models

"Business professional views", GRAI Method



Process Models e.g. BPMN Model

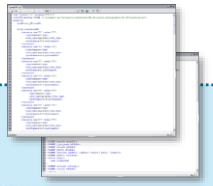


Meta Model

ATL or XSLT Model Transformation

and enrichment

XML Workflow Process Specification



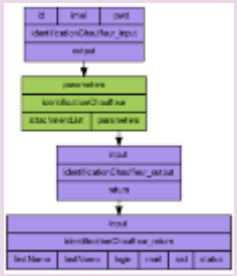
Human behavior and social network modelling

Work of Youssef Bouanan

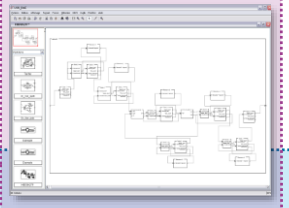
XML DEVS Specification

Work of Judicaël Ribault

Workflow Service

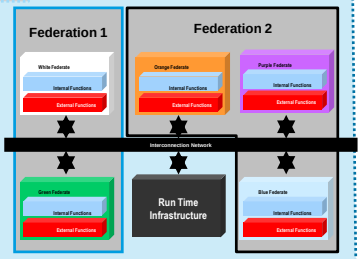


DEVS Simulation

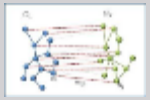


Distributed Simulation

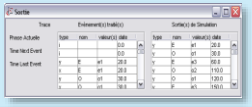
HLA



Ontology Mapping



Works of Fuqi Song



Reverse Engineering

"Model Discovery From legacy systems"

Works of Zhiying Tu

Use of Simulation results to display and animate BPMN model for non expert

Validate behavior

3. Conclusion

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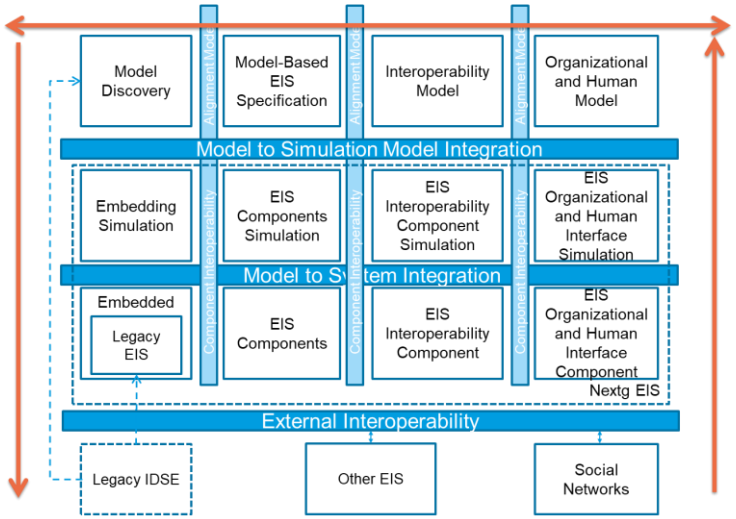
Interoperability happened through a Combination of Methodologies

- Horizontal Interoperability of M&S **Distributed Simulation Standard** + **Matching of ontologies,**
- Horizontal Interoperability of Cyber-Physical Systems **Distributed Simulation Standard** + **Matching of ontologies,**
- Downward Interoperability with **Model Driven Approaches** (MDA, MDI, MDSEA),
- Upward Interoperability with **Process Mining Behavior and Model Discovery,**
- Coupling M&S with **Human and Group Behavior (Models or Real World)**



Areas of application: **Patient Pathways**, **Industrial Processes**, **Risk Management** …

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